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The Relationship between Food Security and Violent Conflict

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1. Introduction

The relationship between food insecurity and violent conflict, as well as the positive relationship between food security and stability, has been a key question in both policy and academic circles for many years. As data availability improves, the volume of research on this topic has steadily increased, supporting wider efforts from the Food and Agriculture Organization (FAO) and World Food Program (WFP) to help secure peace and stability through food availability and security. While research on the relationship between food security and violent conflict has steadily increased, it is still an emerging research theme among economists, political scientists and development researchers. This report provides an in-depth review of the literature on food security and conflict, bringing together multiple streams of research and setting up an analytic framework of food security and conflict as well as econometric and statistical analyses of food security and violent conflict across different degrees of disaggregation.

From both theoretical and policy perspectives, there has been significant research and analysis done on certain aspects of the relationship between food security and peace. Examples include a robust literature on the relationship between food price shocks and the outbreaks of violence in urban settings. But there are also food security and conflict phenomena that remain underexplored, or could benefit from deeper analysis. The relationship between food security and peace durability, the role of resilience for both food security and conflict, and the role and impact pathways of interventions to strengthen both food security and peace are all areas that are under-researched but that hold great promise for making future policies more relevant and effective.

In this report we aim to achieve three outcomes. First, we provide a structured review of the growing body of food security and conflict literature, and organize it thematically to be readily accessible to policy and research audiences. In doing so, we focus on methodologically robust studies which address the interdependency of food security and conflict. Second, we develop an analytic framework of food security and conflict clusters based on the most up-to-date data available using FAO and UCDP databases. Third, these descriptive relationships are then tested at a global level as well as at sub-national levels using innovative research designs. These case studies confirm that the analytic clusters are a valid way to understand the different ways that food security and conflict categories tend to relate to each other. The remainder of this introduction reviews these three outcomes in more detail in turn.

The comprehensive **literature review** explores the bi-directional relationship between food security and violent conflict. Over the last decade the research on this theme has expanded significantly, with significant qualitative and increasingly quantitative work being done across multiple disciplines. The challenge of course is to pull these different disciplinary streams of research into conversation with each other, so we start this report with an in-depth review of the literature on food security and conflict. This not only serves as a standalone resource for researchers and policy makers, but also provides the necessary background to develop an analytic framework around food security and violent conflict.

The **analytic framework** shifts from the theoretical and historical analysis in the literature review to the policy and data oriented aspects of this report. While authors such as Bretthauer (2016) have developed qualitative global frameworks that study the ways that governance affects food security and conflict, we focus on using the data available from the FAO's database in combination with conflict category data from the Uppsala Conflict Data Program (UCDP) and the World Bank to develop clusters of countries depending on the type of conflict and food security issues they face. As conflict becomes increasingly intense and affects more of the country, the impacts on food security shift from being felt at the individual and household level to being more apparent in food price volatility and import dependency. What this tells us is that a country which has a potentially strong government but is facing low-intensity conflict in specific sub-national areas will likely see food insecurity manifest as undernourishment or stunting in those areas; as the intensity and scope of conflict increase, the impacts start to be felt in systems such as food distribution and pricing.

Other findings include:

- Countries experiencing low-intensity but highly localized conflict experience statistically significant higher food insecurity than countries that do not experience this category of conflict.
- Fragile states have, on average, a 10% higher rate of cereal import dependency than non-fragile states. This potentially indicates that fragile states are at a higher risk of violence due to shocks to global food markets.

While the framework provides descriptive relationships between conflict-affected countries and their food security attributes, it is important to use statistical and econometric methods to tease out global patterns in how food security and conflict influence each other. We do this at two levels, developing a set of global models in combination with two case studies that reflect the clusters in the analytic framework.

In the **global analysis** we learn that the *type* of conflict will impact on the way that food security is affected. For example, in cases where the fighting is over control of government we see a higher impact on cotemporaneous and long term food security in comparison to situations where the fighting is over territory. This analysis highlights an important issue facing researchers looking at food security and conflict quantitatively, namely that conflict and food security are measured very idiosyncratically. In many cases it is possible for a conflict affected country to have no food security issues that are visible in the national data even if there is a conflict going on.

To address this, we produce **two case studies** that reflect dynamics identified in the clusters from the analytic framework. The case studies use innovative subnational geocoded conflict and food security data to test empirically the relationships between food security and conflict. The results indicate that in both countries there is a reflexive relationship between food security and conflict and that different conflict categories do indeed relate to different types of food insecurity.

- In **Ethiopia**, when looking at conflict onset at the local level, there is a large and significant relationship between the onset of violence and decreased agricultural production.
- In **Somalia**, geographically disaggregated data on conflict and anthropometric indicators of food security indicate that conflict has a significant relationship with observations of wasting.

What the case studies help highlight is the importance of disaggregated food security data that can be geographically and temporally matched to events of violence. The temporal relationship is particularly crucial, since there are many events of conflict that occur at the sub-national level but it remains difficult to find food security indicators (not proxies or instrumental variables) that measure the same unit of analysis. This supports the initial methodological findings from the theoretical framework, where a key challenge going forward is to harmonize the input and output measures of food security and conflict.

The findings in this report support policy making and research in a number of ways. From a policy perspective, the report brings together streams of data that are rarely directly compared, highlighting both descriptive results that can inform food security policy in conflict-affected countries. It also highlights the need for policy institutions to support hybrid food security-conflict research, creating opportunities to gather data that speaks specifically to the food security-conflict nexus. Crucially, it brings new evidence regarding the food security and conflict relationship, innovatively using subnational data to highlight emerging challenges and opportunities for data-driven food security research and policy making.

2. The Complex Relationship between Food Security and Conflict

The question of the linkages between food security and conflict has been widely and inconclusively debated across disciplines for many years, mainly using qualitative and descriptive methods. In the past few years, the increasing availability of more fine-grained and high-quality data combined with modern econometric approaches has produced a growing body of quantitative findings.

The review is centered around the endogeneity that characterizes the coupling between food insecurity and violent conflict, and focuses on robust findings from rigorous quantitative analyses. It summarizes the existing evidence and highlights limitations in both directions: (i) the impact of violent conflict on food insecurity in Section 2.1 and (ii) the impact of food insecurity on violent conflict in Section 2.2. Section 2.3 presents a brief overview of the roots of the endogeneity problem and key statistical strategies used in the literature to navigate around endogeneity bias. Section 2.4 offers concluding remarks and implications. Section 2.5 provides a brief overview of how the following chapters address some of the existing knowledge gaps and methodological challenges.

2.1 Violent conflict → Food security

It is well-established that differences in food security shape short-term and long-term outcomes of health and well-being, when the ability of individuals and nations to cope with shocks and smooth income and consumption is limited. In conflict-affected countries, many households and firms are smallholder farmers, who face a high degree of income uncertainty even in the absence of conflict, primarily through weather shocks (Townsend 1994; Maccini and Yang 2009). Some are commodity suppliers to local, domestic or global markets, such as cocoa or coffee farmers, which are also subject to price fluctuations in these markets (Deaton 1999; Kruger 2007; Miller and Urdinola 2010; Adhvaryu, Kala, and Nyshadham 2015; Adhvaryu, Fenske, and Nyshadham 2016). In this case, conflict presents an additional \`shock\` that affects the livelihoods and well-being of these populations. Two important points are apparent. First, the nature of this \`shock\` may be quite diverse across different types and intensities of armed conflict and across the national and local institutions that are either transformed or emerge during armed conflict (see also Justino (2012)). Second, exposure to conflict may directly shape food security, but also interact with other fluctuations as those in prices and climatic conditions.

Violent conflict → Consumption

Short-term consequences of nutritional status

A burgeoning literature has identified strongly adverse short-term effects of **early-life exposure** to conflict on children due to their **nutritional status.** The key challenge to assessing the causal chain of impact is that nutritional status may be worse due to other factors than conflict, some of which are a correlate of conflict themselves. If for instance poor households, whose children's nutrition is likely worse even in the absence of conflict, are disproportionately affected by conflict, a simple estimate of the relationship of conflict and nutritional status will be spurious.

Most evidence exists for **anthropometric outcomes**, which are directly associated with nutritional status. These are primarily height conditional on age and gender (HAZ) scores, assessing 'stunting', which is growth failure in a child that occurs over a slow cumulative process. As stunting thus reflects episodes of sustained undernutrition, low scores are associated with 'chronic malnutrition'. A second indicator is the weight conditional on age and gender (WAZ) score. Low WAZ scores are associated with 'general malnutrition'. Third, weight-for-height measures or 'wasting', are often considered the most robust indicator for 'acute malnutrition'.

Many robust analyses rely on a difference-in-differences approach pioneered by studies from Rwanda and Burundi. In Burundi, Bundervoet, Verwimp, and Akresh (2009) show that children **aged 0-5** that were born in regions affected by civil war violence have significantly lower HAZ-scores than those born in other regions. Follow-up studies report consistent, adverse effects on anthropometric outcomes among children from a range of conflict-affected contexts, including Angola, Colombia, Cote d'Ivoire, Eritrea-Ethiopia, India, Iraq and Mexico (Arcand, Rodella, and Rieger 2015; Duque 2016; Minoiu and Shemyakina 2014; Akresh, Lucchetti, and Thirumurthy 2012; Akresh, Caruso, and Thirumurthy 2016; Tranchant, Justino, and Müller 2014; Guerrero-Serdan 2009; Nasir 2016). Akresh, Verwimp, and Bundervoet (2011) find very similar effects of civil war violence on child stunting in Northern Rwanda and contrast the effects with those of a contemporaneous crop failure in Southern regions, that was *not* induced by conflict. The analysis finds important differences between the conflict and non-conflict shocks: war exposure affected all children equally, while in the case of crop failure only girls were negatively affected. This result suggests that during crop failure families could smooth boys' consumption, while during conflict exposure they were not.

In comparison to studies of HAZ-scores, much less econometric evidence exists for weight-based measures. Yet, the few existing studies suggest that violent conflict has strongly negative effects on children's weight-for-age. The causally identified study by Arcand et al (2015) demonstrates that landmine intensity in Angola strongly reduces the WAZ-score. Tranchant, Justino, and Müller (2014) also provide robust econometric evidence, which suggests that political violence in India has a direct negative impact on WAZ-scores. This study also exposes that the mechanisms underlying the strong link between conflict exposure and lower HAZ-scores are not well understood, and likely context-specific. In contrast to WAZ, political violence in India has no direct effect on HAZ, but a negative effect is `activated` for those violence-affected children that were in addition exposed to drought. While speculative, these findings suggest that violence had a negative, indirect impact on HAZ *via* a reduction of the ability of households to cope with drought. Perhaps the richest, rigorous anthropometric study is the one by Guerrero-Serdan (2009), which considers the impact of violence in Iraq on chronic, general and acute malnutrition. The results corroborate the dominant finding in the literature that conflict-affected children are shorter. By contrast, the impacts on WAZ and wasting are weak and inconclusive, providing additional support for the conjecture that the impacts on the different forms of malnutrition differ noticeably.

In summary, the magnitudes of the adverse effects of exposure to armed violence on anthropometric outcomes are markedly similar (and devastating) across case studies and contexts, despite significant differences in conflict duration, war strategies and other context-specific characteristics. Yet, two key limitations of the current literature remain. First, poor nutritional status is often (especially by economists) directly linked to food insecurity. However, a person's nutritional status may or may not be the result of food insecurity, i.e. due to lack of access to sufficient, safe and nutritious food (access defined as physical, social and economic). For instance, stunting may be caused by repeated infections as well. Causal statements on the link between conflict and food security hence require increasingly careful and systematic discussions of these alternative mechanisms. Second, most of the rigorous and robust evidence documents adverse effects in chronic malnutrition, rather than general and acute malnutrition. However, acute malnutrition indicators in particular are critical nutritional status indicators which should be closely monitored and analyzed in conflict countries and protracted crisis countries and serve as a key source of information for humanitarian interventions. Thus, more rigorous evidence on the impact on acute malnutrition seems of paramount importance.

An important related question is the extent to which conflict-induced undernutrition increases the **mortality risk**. This intuitive link has been described by a long line of descriptive research in public health (Chen, Chowdhury, and Huffman 1980; Young and Jaspars 2009),[1] but causally identifying and especially quantifying this link is particularly difficult. The reason is that common unobservable factors, such as genetic endowment or conflict-time food and health systems, are very likely to affect both nutrition and mortality directly. Yet, there is now robust evidence confirming that the link is substantive and substantial. In a rigorous study from Burundi, for instance, Verwimp (2012) estimates that the nutritional deficiencies from one year of conflict exposure causally increased boys' mortality risk by 25 percentage points.

A related body of evidence shows that adverse short-term effects of conflict on children through nutritional channels may already be activated before a child is born ('**in-utero**'). Pregnant women who are exposed to (more) conflict give birth to children of lower weight – which, thus immediately transmits adverse effects of conflict across generations. The pioneering study by Camacho (2008) finds that the exposure of women to violence across Colombia during the first three months of pregnancy resulted in lower birth weights. These effects have been confirmed by findings from diverse contexts, such as Brazil, Mexico, Nepal, Kashmir and Palestine (Foureaux Koppensteiner and Manacorda 2016; Brown 2015; Valente 2011; Parlow 2012; Mansour and Rees 2012).[2] While the relationship between conflict exposure in-utero and birth weight is robust, questions about the underlying mechanisms – which are likely to be highly context specific – and the impacts on measures such as height as a child are hitherto only inconclusively debated (Akresh 2016).

Long-term consequences of nutritional status

The famous `fetal origins hypothesis` posits that variation in access to nutrition in the womb codes *long-run* differences in health and well-being. The original hypothesis has been extended to early-

[1] Recent estimates of mortality from war and interpersonal violence reported values around 0.5–1 million deaths annually (e.g. Lozano et al. 2012).

[2] While the reduced-form link is very robust, it is worth noting that disentangling nutritional channels from others, such as effects of maternal stress that do not work via nutrition, empirically is very difficult.

life nutrition after birth and affirmed by a large body of empirical evidence, which is reviewed by Almond and Currie (2011) and Currie and Vogl (2013).

A few recent studies have started to produce robust support for such detrimental **long-term impact** of conflict exposure early in life. Damaging effects on physical and cognitive development outcomes as an **adult** have been reported from various other conflict-affected settings, for instance Cambodia, Germany, Mozambique, and Zimbabwe (de Walque 2006; Akbulut-Yuksel 2014; Domingues and Barre 2013; Alderman, Hoddinott, and Kinsey 2006). The important study by Akresh et al. (2012) provides convincing evidence that the magnitude of the impact may war vary significantly by age at exposure 40 years after the end of the conflict. They show, for instance, that women who had been exposed to the Nigerian civil war in Biafra between 0 and 3 years of age are, on average, 0.75 centimeters shorter than non-exposed women of the same age. Women who were exposed when they were 13 to 16 years old are 4.53 centimeters shorter than non-exposed women of the same age. These strong heterogeneities remain to be validated across other conflicts and contexts.

Taken together, the literature has rapidly accumulated a wealth of robust micro-evidence that the exposure to conflict at a young age is causally linked to irreversible harm to short- and long-run development from nutritional disadvantages. What aspect of violent conflict causes these nutritional deficits, and how, remains not well understood, and is likely to include multiple and context-specific pathways.

Coping and consumption

To better understand reactions to conflict exposure and associated impacts on outcomes related to food security, a third line of literature directly studies micro-strategies to reduce conflict risk and smooth consumption (Justino 2009).[3] As suggested by descriptive evidence these strategies are dynamic and likely to differ at conflict onset and during protracted conflict (e.g. Ogbozor 2016).

Most existing reliable knowledge describes **migration and forced displacement**, and documents a wide range of adverse effects on food security. Several quantitative studies rely on refined household survey data related to the quantity and quality of consumption, despite the challenges to thorough data collection in these regions. Indicators include activity choices, detailed consumption diaries, resulting calorie intake data, food expenditures, food produced, food gifts combined with local food price data. However, teasing out and quantifying causal relationships is once again daunting and robust evidence is thus rare (see review in Ruiz and Vargas-Silva (2013)).

A few convincing studies validate and confirm the correlational evidence. Kondylis (2010), for instance, exploits differences in the timing of *return* of Rwandan internal refugees to establish that returnees are significantly better off economically than those who had (still) remained displaced. Bozzoli, Brück, and Muhumuza (2016) produce meaningful comparisons of residents of internal displacement (IDP) camps in post-war Northern Uganda and those who had just relocated from camps voluntarily. The study finds significant differences in activity choices: while camp residents

[3] Especially for self-sufficient farmers this obviously also concerns re-allocations of labor and capital in agricultural production, which we discuss later.

are less active overall (which may suggest their productivity is low), they are more likely to cultivate and trade. In the same region, Fiala (2015) exploits a geographic discontinuity of placements into IDP camps in Uganda and compares displaced to non-displaced household at two points in time: i) when displaced household were in IDP camps and ii) two years after their return. Households in IDP camps had significantly lower levels of consumption and assets than comparable non-displaced households. Two years after returning home, households that did *not* belong to the poorest quarter of displaced households before leaving, had managed to return to the welfare levels of non-displaced households, while the poorest households had not. Verwimp and Munoz-Mora (2013) find similar effects on food expense and calorie intake among Burundian refugees. The study estimates that it would take 8-10 years after return for the welfare gap between displaced and non-displaced household to close. These findings suggest that displacement may have strongly adverse long-term legacies, which - without assistance - may be impossible to overcome for the poorest populations. Ruiz and Vargas-Silva (2015) study the local labor markets of host communities in Tanzania that took in Rwandan and Burundian refugees, and rely on a natural experiment induced by a mix of geographical barriers and transportation costs for identification of the local shock in labor supply. The results suggest that the supply shock had no noticeable impact on self-employment choices of the native population, including farming and livestock care, but reduced the likelihood of taking up employment outside the household. For the case of internal displacement, Bozzoli, Brück, and Wald (2013) show that in Colombian communities the probability of self-employment decreases when many people leave, and increases when many people arrive.

Beyond displaced populations, other studies have investigated food consumption patterns in **conflict zones** more generally, and link it to conflict event data. As expected, the findings confirm that households living close to registered conflict events often experience drops in consumptions levels in settings as diverse as Afghanistan (D'Souza and Jolliffe 2013), Cote d'Ivoire (Dabalen and Paul 2014) and Rwanda (Serneels and Verpoorten 2015).

Beyond violence, an emerging literature offers descriptive evidence on the local presence and **rule of armed state and non-state groups** (Arjona, Kasfir, and Mampilly 2015). One the one hand, such groups often invest in local public goods (Sanchez de la Sierra 2016), which may increase local consumption levels, but one the other hand, food is essential for the survival of an armed groups (e.g. Justino and Stojetz 2016) , which may decrease local consumption levels. At the extreme end of the spectrum, these processes also include scenarios where food and hunger are used as ``a weapon of war`` (Messer and Cohen 2015). Yet, collecting micro-data on these processes is difficult, and to the best of our knowledge these effects have not been studied and quantified systematically.

Direct, and indirect, studies of consumption are surprisingly scant at **aggregate levels**. The early study by Teodosijević (2003) reveals that among 38 countries the experience of conflict between 1961 and 2000 is associated with a 7-percentage point reduction in daily energy supply. Jeanty and Hitzhusen (2006) find similar results based on 73 countries between 1970 and 2002. Gates et al. (2012) present perhaps the most extensive set of reliable estimates of the impact of conflict on food security and underdevelopment at the cross-national level. Key findings include that a conflict with 2500 battle deaths increases the share of population living on less than the minimum recommended dietary energy consumption by 3.3%, and denies an additional 1.8% of the population safe access to potable water.

The negative correlation between conflict and food security is confirmed by a few more robust studies at the subnational level. At the district level, Merrouche (2008), for instance, provide convincing evidence that variation in landmine contamination reduces consumption levels in Mozambique a few years after the end of the conflict, while Miguel and Roland (2011) and Dell and Querubin (2016) demonstrate that bombing intensity in Vietnam has no significant impact on consumption levels in the long run.

Violent conflict → Production
Economic production

An extensive literature has investigated the effects of civil war on economic production and growth across countries.[4] One of the key studies to motivate this literature is the widely-cited paper by Collier (1999), which contends that during civil wars GDP per capita declines at an annual rate of 2.2%. Since then, it has become apparent, however, that civil wars have highly heterogeneous effects on economic production across countries. The case-by-case study analysis by Bove, Elia, and Smith (2016) shows that, on average, civil war reduces GDP by 9.1%. Yet, only 12 of the 27 cases show a significantly negative effect of war on GDP, and country responses to civil war span a range from -33% to 32% of GDP.

Looking at conflict-affected areas within countries, a small body of recent works finds robust evidence that regional economic performance often converges quickly to levels of regions that were not directly affected (e.g. Davis and Weinstein 2002; Brakman, Garretsen, and Schramm 2004; Lopez and Wodon 2005; Miguel and Roland 2011). Such a **convergence** is – under certain additional conditions – consistent with predictions from a simple Solow growth model, when capital and labor are mobile. As most of the evidence comes from variation in bombing intensity, these results have been interpreted as evidence that the recovery from destruction, particularly that of infrastructure, is often rapid. Related, a few studies have confirmed the hypothesis by Collier (1999), that sectors most dependent on either capital or transaction are most vulnerable to conflict violence, but also recover quickly (see e.g. the district-level analysis by Vothknecht and Sumarto (2011) for Indonesian industries). By contrast, a recent innovation by Martinez-Cruz and Rodríguez-Castelán (2016) uses Mexican homicide rates to demonstrate that intense violence with a relatively low rate destruction of physical capital *does* strongly increase the risk of chronic poverty at the district level.

A few recent studies have used innovative farm-level and conflict data and modern techniques to analyze the causal impact of violent conflict in East Africa and Colombia on **agricultural production**, including livestock and a variety of crops, such as coffee. The findings suggest that production may drop substantially in regions affected by conflict, due to adverse effects on labor supply, access to land and access to credit and/or direct effects on capital as theft and destruction

[4] For a surveys on the economic costs of conflict see, e.g., de Groot, Bozzoli, and Brück (2015).

(Nillesen 2007; Verpoorten 2009; Rockmore 2015; Munoz-Mora 2016; Blattman and Miguel 2010).[5]

Among the important factors shaping heterogeneous responses to conflict are likely the impacts of violent conflict on social, political and economic **institutions** (including markets). While the long-term effects on economic performance, including food production and food security, could be positive or negative, these are still among the least understood of all impacts of violent conflict (Blattman and Miguel 2010). In the short-run, the recent study by Dell and Querubin (2016) finds that bombing in Vietnam increases socio-political collective action by local populations. Gáfaro, Ibáñez, and Justino (2014) provide similar evidence on positive impacts on collective action in Colombian areas where armed groups are present. Increased collective action as a social institution may boost productivity and food security when it helps to establish networks and to solve coordination problems. Sanchez de la Sierra (2016) shows that – under certain circumstances – bandits in Eastern Congo establish institutions to stimulate local economic activity, at least temporarily. A different set of studies emphasizes that conflicts may have strong impacts on land use, tenure and systems, but generalizable findings are to date scarce (see review in Baumann and Kuemmerle (2016)). Overall however, institutional change, which characterizes most violent conflicts, and the impacts on production remain very poorly understood, both at the national as well as the local levels.

Productivity

Researchers have also started to document robust mechanisms how the exposure to conflict may threaten individuals' and households' food security in the short- and long-runs via productivity. There is ample evidence for largely adverse effects of conflict on **human capital** outcomes and accumulation. The pioneering study by Akresh and de Walque (2008) shows that the armed conflict in Rwanda caused exposed children to complete half a year less of formal education, on average. To give a few examples of follow-up studies, Shemyakina (2011) presents similar evidence of the negative impact of civil conflict on schooling in the case of Tajikistan, Chamarbagwala and Morán (2011) find a strong negative effect of the civil war in Guatemala on the education of Mayan men and women in rural areas, the most disadvantaged groups. Blattman and Annan (2010) find that child soldiering significantly interrupted and reduced schooling accumulation in Northern Uganda. Yet, the effect of violent conflict on education is not universally negative. Arcand and Wouabe (2009), for instance, find that conflict increased school enrollment in Angola. Related, more recent research has documented causal impacts on health-related outcomes which are often not the result of nutritional channels, including disabilities and mental health (Palmer et al. 2016; Groce et al. 2016; Bratti, Mendola, and Miranda 2016).

A few original studies have now also shown that the exposure to conflict may alter **behavioral parameters**, which are also related to individual and collective production of food security. A meta-analysis by Adhvaryu and Fenske (2014) finds that growing up near conflict has no effect on political attitudes as an adult. Yet, more refined measurements of conflict provide strong evidence that certain experiences make individuals to behavior more pro-socially in the long-term. A

[5] We discuss the household- and farm-level decisions underpinning most of these results below.

growing literature documents such an effect for the exposure to violence (Bauer et al. 2016), while Justino and Stojetz (2016) show that the exposure to wartime governance with armed groups causes Angolan veterans to behave more pro-socially. The important study by Voors et al. (2016) demonstrates that the exposure to violence alters risk and time preferences, which has been replicated by a few recent studies (e.g. Jakiela and Ozier 2016; Rockmore, Barrett, and Annan 2016).

Coping and agricultural production

As noted above, observing actual micro-level responses to conflict exposure in-situ is particularly challenging, but there is growing empirical evidence on the coping strategies by conflict-affected individuals and households to protect their productivity, livelihoods and food security. As for instance in Africa 70 percent of the population rely on agriculture for their food supply (Paul, Shonchoy, and Dabalen 2015), the literature has focused on **agricultural coping strategies**. Well-documented strategies include shifts in crop production portfolios, labor reallocation, destroying or hiding livestock (and other visible assets), changes in land use patterns, economic cooperation with local ruling groups and (other) activities that minimize victimization risks and uncertainty (e.g. Bozzoli and Brück 2009; Brück and Schindler 2009; Verpoorten 2009; Rockmore 2011; Arias, Ibañez, and Zambrano 2012; Fernández, Ibañez, and Peña 2014; Gáfaro, Ibáñez, and Justino 2014; Menon and van der Meulen Rodgers 2015).[6]

Several studies emphasize that shifts in crop, livestock and asset portfolios are often consistent with households increasing the share of low-risk, low-return activities (e.g. Vlassenroot 2008; Justino 2009; Paul, Shonchoy, and Dabalen 2015; Rockmore 2015). These low-risk low-return coping strategies may obviously have adverse long-term consequences, but may also provide immediate and longer-term *benefits*. In terms of benefits, Brück (2003) and Bozzoli and Brück (2009) for instance, show that during the civil war in Mozambique subsistence farming led to improvements in the economic security of households living in extreme poverty because social and economic markets entailed limited welfare benefits. These effects of subsistence modes of production during conflict must, however, be balanced against the longer-term adverse effects of low productivity. In addition, the external validity of this finding is contested. Nillesen and Verwimp (2010), for example, show that many Burundian households exposed to high levels of conflict violence shifted their portfolios towards more sustainable, and more profitable, activities, and that income shares from export crop farming were higher in violence-affected regions (even though the causality may have run from export cropping to conflict in this case).

Key Limitations

In sum, a rapidly expanding literature studies food-security related impacts of violent conflict at the micro- and macro-levels. The existing evidence suggests that individuals, households,

[6] Notably, some of these strategies differ from findings from reactions to non-conflict shocks. For instance, selling – rather than hiding or destroying – livestock, is documented as a common form of coping strategy used by rural households in developing countries in times of crisis.

communities and regions face serious constraints in coping with conflicts and maintaining adequate nutrition levels and food security.

Based on the increasing availability of more fine-grained and high quality conflict data combined with innovative identification strategies, most robust quantitative findings concentrate on the micro-level. These have primarily established that a causal link exists between the exposure to violent conflict and short-term and long-term outcomes related to food-security. The most robust finding in the literature is that individual exposure to civil war events as a child may result in strongly adverse and often irreversible effects on physical and cognitive development, which may transmit risks across generations.

Among others, three critical gaps in knowledge are apparent. First, researchers have only started to explore the causal mechanisms underpinning the strong association between conflict exposure and food insecurity (and its legacies). For example, it has not been tested well if and when economic, psychological/behavioral or institutional conflict channels contribute relatively more to the adverse effects on food security. In addition, it remains to be understood how these conflict channels and climatic stresses differ, combine and interact in their impact on food security. This gap is addressed in Chapter 6.

Second, the rigorous evidence on factors related to food security at aggregate levels beyond economic outcomes – such as GDP – is comparably weak. The pronounced scarcity of systematic studies of aggregate food consumption indicators – such as dietary energy supply – is surprising, and severely limits our capacity to understand and monitor the impact of conflict on food security globally. This gap is addressed in Chapter 4.

Third, at all levels conflict exposure is still predominantly modelled via events of civil war violence. At the micro-levels, exposure is proxied by the proximity to battle events and violence, while at the regional and country-levels typically battle deaths are counted. These are crude measures, and better data is required to capture aspects of conflict beyond violence – such as local conflict economies and governance – and more data from other types of violent conflict than civil war. This lacuna particularly includes meaningful and causally identified studies of fragility, which at the micro-level are almost absent. Taking dis-aggregation seriously requires conflict exposure or fragility exposure data at the individual level, collected for example with survey data (Brück et al, 2016).

These knowledge gaps constrain the capacity of policy makers and practitioners to assist local and national populations with coping with conflict and fragility and with smoothing food security. While not the primary focus of this review, it is also evident that rigorous micro-level evaluations of (any) policy in fragile and conflict-affected settings are rare. Naturally, such analyses faces manifold and enormous challenges inherent to conflict, but recent research hast started to explore how to better design, implement and evaluate policies in conflict zones (Bozzoli, Brück, and Wald 2013a; Puri et al. 2014; Brück, Ferguson, Izzi, and Stojetz 2016).[7]

[7] We resume the discussion of food security policies in the next section.

2.2 Food security → Violent conflict

The study of food security has attracted wide attention recently. Analyzes have predominately focused on a conceptual understanding of food insecurity, such as lack of dietary energy availability and nutrient deficiencies, and how to alleviate these concerns. While a large body of literature has studies the impact of broad categories of economic and ethnic differences, such as in growth or religion (for a recent review see Ray and Esteban (2016)), researchers and practitioners have only recently started to study food insecurity's consequential social and political implications comparatively and rigorously (for a broad overview see, e.g., Koren and Bagozzi (2016)).

Two important points are obvious. First, food security aspects relevant for conflict zones and societies may be very diverse and may vary substantially across different types and intensities of armed conflict and income levels. Second, impacts originate from and operate at very different levels. At the individual and household levels, factors such as nutrition and economic opportunity may directly affect participation in virtually any forms of anti-social behavior. A range of additional mechanisms may originate at more aggregate levels, including global food prices and policies as well as domestic and local wartime institutions, markets, governance and climatic conditions.

Food insecurity → Anti-social behavior

At the individual level, food insecurity – or the threat thereof – may create both material and non-material incentives for individuals to engage in some form of behaviour that threatens peace (to which this section will refer to as 'anti-social behaviour').

Economic explanations are dominated by **opportunity-cost** theories in the vein of early models of crime (Becker 1968; Ehrlich 1973). This logic has been applied to other forms of behaviors relevant to this research, including collective forms of rebellion and violence (e.g. Collier and Hoeffler 1998; Collier and Hoeffler 2004). Food insecurity may thus be a factor that reduces the opportunity cost of individuals joining or supporting armed factions, thereby increasing the feasibility of armed conflict. Each person weights the relative costs and benefits of engaging in criminal activities and does so when the expected gains are greater than the costs (see Draca and Machin (2015) for a review of supporting literature). Dominant alternative theories emphasize political calculations (Tilly 1978) and that many individuals seek to voice discontent and **grievances** (Gurr 1970). For most people food insecurity and poverty are distressing, which can activate grievances and cause frustrations and anger, leading individuals to engage in anti-social behaviors (see e.g. Blattman and Miguel (2010)). Specifically, this includes frustrations with and mistrust in the state, which may originate from sentiments of a lack of state support when facing food insecurity (e.g. Wischnath and Buhaug 2014).

Pinning down a single channel empirically is extremely difficult, however, and rigorous empirical evidence at the individual-level is therefore markedly thin. Two key challenges are that these motives are a) in and of itself are very complex and hence difficult to measure and b) empirically extremely difficult to untangle from alternative mechanisms that are often credibly not directly related to food insecurity, such as abduction, peer-pressure, ideology, and emotions.

The evidence most closely related to food security investigates individuals' motivations to **join armed groups**. To illustrate, some studies provide support that some individuals chose to participate in and support armed groups because they may gain from the conflict in terms of improved economic opportunities, looting and appropriation (Keen 1998; Hirshleifer 2001). A related argument is that people sometimes opt to join an armed group because *non*-participation is directly riskier in terms of both physical and economic survival (Kalyvas and Kocher 2007; Justino 2009). These concerns may essentially reflect food insecurity. Walter (2004) and Justino (2010), among others, describe how destitution and poverty lead deprived individuals to support and participate in armed groups. The pioneering studies of ex-combatants by Humphreys and Weinstein (2008) provide perhaps the most compelling empirical evidence. Based on original survey data they show that armed groups sometimes target recruits via basic needs, providing food, shelter and physical security.

More recently, a growing number of (mostly descriptive) accounts has emerged that documents how civilians survive and protect their livelihoods and food security through forms of **support for armed groups**, which may voluntary or involuntary. These processes are endogenous to 'wartime governance' by local ruling groups and underline the centrality of shelter, food and information to the fate of armed groups (Wood 2003; Kalyvas 2006; Arjona, Kasfir, and Mampilly 2015; Justino and Stojetz 2016). It is apparent, however, that rigorous evidence beyond descriptive and qualitative analyses is very scarce.

Food prices → Violent conflict
Historical accounts are replete with descriptions how rising **food prices** breed violent conflict, including insurgencies, wars and revolutions (Rudé 1964; Goldstone 1991; Diamond 2005). There is now a growing body of econometric evidence – broadly in the vein of Hendrix, Haggard, and Magaloni (2009) – that supports this conjecture for the incidence of very different forms of social unrest, such as protest and riots, violence and war, with most studies relying on FAO's price index of food commodities.

Most evidence exists for **urban** social unrest in contemporary Africa (e.g. Berazneva and Lee 2013; Smith 2014; Bellemare 2015), which includes studies linking the 'Arab Spring' uprisings to international food price shocks (e.g. Johnstone and Mazo 2011; Maystadt, Trinh Tan, and Breisinger 2014); more recent findings suggest global relevance (Cadoret, Hubert, and Thelen 2015). Studies of the intensive margin of violent conflict are more scarce, but point to broadly similar, positive relationships with increasing food prices (see e.g. Breisinger, Ecker, and Trinh Tan 2015; Maystadt and Ecker 2014). By contrast, much less is known on *how* and *how much* food prices drive violent conflict. Among the most fundamental unsettled questions is whether and when it is the level versus the volatility of food prices that breeds conflict. In this regard, the most convincing evidence is provided by Bellemare (2015) who forcefully argues that increases in food price **levels** cause urban unrest, while those in food price volatility do not.

The dominant explanation for the food price-conflict link are **consumer grievances**: higher prices essentially create or increase economic constraints and/or sentiments of (perceived) relative deprivation, which activates grievances that in turn lead to conflict. Yet, this causal chain is very difficult to both measure and isolate empirically, for reasons already noted above, which is why it is usually assumed rather than tested directly. In addition, most contributions have looked at the impact of international food prices on conflict at the **national level**, which is reasonable in principle, as many fragile and conflict-affected countries are net importers of food. A few recent studies, however, emphasize the need to use country-specific food price indexes to better understand the consumption patterns and constraints faced by vulnerable populations (e.g. Arezki and Brueckner 2014; Cadoret, Hubertt, and Thelen 2015; Weinberg and Bakker 2015). In an innovative study using such an approach based on a country's food import pattern, Van Weezel (2016) provides three statistically robust and important findings: 1) the (previously documented) relationship between food prices and urban conflict is driven mainly by the prices of basic staples like wheat, and 2) is predominantly supported for high-intensity conflict, but 3) interestingly, the magnitude of the effect as well as the predictive power of food prices are both notably moderate.

A second set of explanations for the food price-conflict link emphasizes breakdowns of **state authority and legitimacy** when the state fails to provide food security, i.e. activating grievances against the state (e.g. Lagi, Bertrand, and Bar-Yam 2011). A few recent analyses have sought to document the related impact on state-level correlates of conflict. Arezki and Brueckner (2014), for instance, argue that the cohesiveness of political institutions in low-income countries deteriorate significantly when international food prices increase while Berazneva and Lee (2013) show that rising food prices and riots in Africa are associated with more political repression.

Food production → Violent conflict

While many developing countries – especially in Africa – increasingly rely on food imports for domestic consumption, agriculture often remains the largest economic sector, delivering labor opportunities and sustaining livelihoods. A third large strand of literature thus focusses on the role of variation in **food production** on violent conflict. As in many developing countries food production is strongly dependent on climatic conditions, a lot of evidence exists on variation induced by climatic fluctuations, which is review separately in the next section.[8]

Income drops from agricultural production may directly lower the **opportunity cost** of engaging in anti-social behaviour (Miguel, Satyanath, and Sergenti 2004). Guardado and Pennings (2016) for instance, show that conflict intensity in Iraq and Pakistan is higher outside the harvest season, when demand for labor in agriculture is lower. More generally, decreases in agricultural productivity may directly activate societal **grievances** due to, e.g. increasing destitution, famine, distress, migration, or aggravated social inequalities (Barnett and Adger 2007; Raleigh and Kniveton 2012; Kelley et al. 2015; Reuveny 2007; Raleigh 2010). A third source of violent conflict discussed in the literature are increased grievances against the state, when **agricultural deficits** at *the state level* result in losses of tax revenues and higher food prices, as discussed above (Homer-Dixon 1999; Kim 2016). In this case, associated forms of maldistribution, patronage, corruption,

[8] In Africa, for instance, merely 6% of the all food production is irrigated (NEPAD 2013).

embezzlement of aid may then also activate or exacerbate existing grievances against the state (Benjaminsen 2008; C. Hendrix and Brinkman 2013; Nunn and Qian 2014).

From a production point of view, increased international commodity prices – including **agricultural commodities** – should *benefit* domestic producers of the commodity and *reduce* conflict (see e.g. discussion in Smith (2014)). On the other hand, ruler capture of increased revenue could, of course, lead to the opposite outcome, i.e. *more* conflict, driven, for instance, by grievances against the state. These basic considerations suggest that fluctuations in commodity prices may affect subpopulations and subregions in conflict zones very differently. While of paramount importance, researchers have just begun to develop rigorous studies and frameworks to analyze these processes empirically. A few recent contributions provide initial but very sound insights. As predicted, McGuirk and Burke (2016), for instance, demonstrate empirically that for African food-producing grid-cells increases in world commodity prices can *reduce* the incidence of (large-scale) conflict over land and the control of territory (``factor conflict``). Conversely, higher prices can *increase* the incidence of (small-scale) conflict over the appropriation of surplus (``output conflict``).[9] The innovative study by Wright (2016) shows how Colombian rebel tactics respond to fluctuations in world coffee and coca prices. Drops in coffee prices allow and cause rebels to use more intense conventional fighting (as economic opportunities outside of rebellion are argued to be low), while dropping returns to coca production lead to irregular rebel attacks (as rebels are argued to be more resource constrained).[10]

Climate → Violent conflict

A related and burgeoning literature focuses on the quantitative links between variation in climatic conditions and conflict (see, e.g., the recent review by Burke, Hsiang, and Miguel (2015)). The basic motivations underlying most studies can be classified into two categories. One large set of studies essentially seeks to understand the impacts of climate change and variation in climatic conditions, and are primarily interested in the `reduced-form` link between climatic variation and conflict outcomes. Studies in the second category originate from the question how economic conditions and production affect conflict outcomes, and primarily study (and exploit) the impacts of climatic variation on economic variation as a first-stage process of the analysis. Reduced-form effects can thus be interpreted as the net impact of climate on conflict, as in Burke, Hsiang, and Miguel (2015). The impact may be substantiated by multiple pathways, which are very likely to be closely related food security, and include those operating via economic conditions and outcomes.

Most attention in the literature has focused on assessing whether empirical estimates of the purported **reduced-form** link are spurious and have a causal interpretation. Studies from numerous settings find that both above average temperatures and below average precipitation levels are

[9] While not related to food production, Sanchez de la Sierra (2016) complements these findings conceptually by showing that bandits in Eastern Congo are more likely to invest in monopolies of violence and public good provision when world prices of Coltan — an output that can be taxed — rise.

[10] For studies of subnational income shocks and political violence in Colombia see, e.g., Bazzi and Blattman (2014) and Dube and Vargas (2013). For investigation of the form other contexts see, e.g., Jia (2014); Fjelde (2015); and Vanden Eynde (2015).

positively associated with conflict onset and duration, starting with an influential analysis on temperature and civil war incidence by Burke et al. (2009). Others have contested the existence of this relationship and highlight that such a conclusion may be flawed, due to measurement error, dataset selectivity, and methodological strategies (Buhaug 2010a; Buhaug 2010b; Sutton et al. 2010). Yet, the leading perspective now is that the climate-conflict link is real (Burke, Dykema, et al. 2010; Burke, Miguel, et al. 2010a; Burke, Miguel, et al. 2010b), which is backed up by recent meta-analyses of 50+ prior studies documents substantial effects of temperature increases on the likelihood of interpersonal and intergroup conflict (Hsiang, Burke, and Miguel 2013; Burke, Hsiang, and Miguel 2015).[11]

Beyond the basic debate on the existence of the climate-conflict link, two observations from this relatively recent literature are worth noting. First, existing studies have nearly exclusively focused on sub-Saharan and Sahelian regions in Africa. Second, there is a very active debate whether and how the effect of climate on conflict operates through local economic conditions. The focus on this specific pathway is partly driven by the interest in understanding the effect of economic conditions on conflict, as noted above. The first step in the chain of causation via **local economic conditions** is that unusually high temperatures and low rainfall depress agricultural production and output, which, for Africa, is not disputed (e.g. Barrios, Ouattara, and Strobl 2008; Schlenker and Lobell 2010). While the intuitive link with an associated drop in food security is often essentially assumed, a number of studies have explicitly documented negative impacts of climatic variation on household food security (see, e.g., for Ethiopia, Dercon and Krishnan 2000; Demeke, Keil, and Zeller 2011; Di Falco, Veronesi, and Yesuf 2011).

In the second step, diminished agricultural yield and incomes are theorized to drive conflict by affecting local employment opportunities, prices, and grievances. Subsequent studies have thus sought to predict the consequences of climate change on violence levels by extrapolating from historical temperature and rainfall trends in **rural Africa** (e.g. Gleditsch 2012; Hendrix and Salehyan 2012; Raleigh and Kniveton 2012; Theisen 2012). Yet, the mechanisms substantiating this second step remain largely untested empirically. Raleigh, Choi, and Kniveton (2015) demonstrate the complexity of these relationships and the difficult to untangle them empirically, but also provide rare convincing evidence how the link from climatic variation to conflict can flow via food prices.

Recent research points to alternative mechanisms how **temperature** anomalies may be related to conflict. Temperature-induced variation in agricultural yield can alter migration patterns, with potential effects on sub-state violence and conflict (Salehyan and Gleditsch 2006; Hsiang, Meng, and Cane 2011; Feng, Krueger, and Oppenheimer 2010; Feng, Oppenheimer, and Schlenker 2012; Bohra-Mishra, Oppenheimer, and Hsiang 2014). Excessive heat may also reduce the broader supply of crops, raising the price of food (see above). Temperature anomalies also have effects on

[11] As Burke, Hsiang, and Miguel (2015) point out most studies look at locally linear relationships suggests, while the global relationship between temperature and conflict is u-shaped. Yet, it is argued that most modern societies are now on the warm, upward-sloping portion of the response curve, which validated the linearization. Non-linearities in the relationship between precipitation and conflict are discussed below.

economic activity beyond agricultural production. Several studies have documented that higher temperatures may depress economic output and growth, which may lead to conflict (Hsiang 2010; Jones and Olken 2010; Dell, Jones, and Olken 2014; Carleton and Hsiang 2016). While these economic factors may well be linked to food security, empirical psychological research at the individual-level has long established the tendency of individuals to behave more violently due to higher temperatures (Burke, Hsiang, and Miguel 2015). These mechanisms are likely to interact with conflict risks due to food security, and it is also possible that food security-based mechanisms are weak or even absent. The recent study by Bollfrass and Shaver (2015) provides an interesting finding: using new global data at the provincial level they document the universal existence of a temperature-conflict link, which also obtains in regions *without* agricultural production.

The bulk of the (markedly inconclusive) empirical studies linking **precipitation** and violent conflict aggregates rainfall during calendar years and over the totality of a country's territory. A few recent studies provide evidence from spatially and temporally more disaggregated cells. The spatially disaggregated study by Theisen, Holtermann, and Buhaug (2011) finds no association between yearly rainfall dynamics and civil war battle events, while von Uexkull et al. (2016) argues that sustained drought is more likely to lead to conflict in locations with rain fed agriculture in Sub-Saharan Africa. The grid-cell analysis for Africa by La Ferrara and Harari (2015) documents that negative shocks to rainfall during the growing season increase the risk of inter-group violence incidence. Related, Crost et al. (2015) show for the Philippines more rainfall during the dry season decreases the risk of violent events while it *increases* the risk during the *wet* season. The recent paper by Maertens (2016) focuses on agricultural cells and explicitly incorporates the economics of agricultural production, i.e. that there is a non-linear relationship between rainfall and agricultural output. The study demonstrates that the hump-shaped relationship of rainfall and output in agricultural cells translates into a u-shaped relationship between rainfall and civil conflict risk at the country level: a substantial increase at comparably low levels of rainfall reduces the risk of civil war onset, while the same shift occurring above a certain threshold in levels *increases* the risk of civil war onset.[12]

Food security policies → Violent conflict

With respect to policy interventions related to food security, arguably the most prominent literature is a broad body of empirical studies analyzing the impact of **foreign aid and assistance** on conflict outcomes. This literature is clearly very important, but it is also one of the most controversial ones in the fields of development and conflict. Theoretical models suggest that broadly that the welfare effects of material aid in fragile and conflict-affected settings is ambiguous, depending on factors such as the 'cohesiveness' of political institutions and the level of government capacity, while technical assistance (if effective) should reduce conflict (Besley and Persson 2011). The key empirical issue is that – by construction – aid assistance is not randomly allocated. The existing evidence from both within as well as from across countries is markedly mixed. Depending on the

[12] For related recent contributions on the two-step effects of precipitation anomalies, including droughts and floods see also Buhaug et al. (2015), Ghimire, Ferreira, and Dorfman (2015) and von Uexkull et al. (2016). Another example of a study of a wide range of rainfall levels is Hidalgo et al. (2010), which documents a strongly non-linear relationship between rainfall and land invasions in Brazil.

measures used, the level of aggregation, the empirical strategy employed, and the context, results range widely from very negative to very positive impacts of aid on conflict (see e.g. Galiani et al. 2016).[13]

The statistically most robust and most direct evidence on conflict outcomes is from a few recent studies that use new high-quality data and exploit natural or randomized variation in particular types of foreign aid to identify its causal effects. Perhaps less intuitive findings include that conflict risks increased due to U.S. military aid in Colombia (Oeindrila Dube and Naidu 2014), due to U.S. food aid to low-income countries (Nunn and Qian 2014) and via community driven development aid in the Philippines (Crost, Felter, and Johnston 2014). Related, other studies find that foreign aid can reduce political accountability, e.g. in Uruguay (Manacorda, Miguel, and Vigorito 2011), but that this problem may be mitigated by publicly providing more, and more transparent, information about aid allocation (Guiteras and Mobarak 2015).

Beyond aid, many sub-national interventions related to food security, including in conflict-affected settings, exist, of course, and many have successfully relieved food security stresses. While surveying these is beyond the scope of this section and deserves an entire literature review in its own right, the actual impacts of improved food security status on reducing conflict risk appear to be highly context specific and are often assumed rather than tested rigorously. This encompasses various forms of food security and also includes innovative policies that build resilience (e.g. Breisinger et al. 2014).

Key Limitations

In sum, a wealth of studies from many disciplines has associated food insecurity with the incidence, duration and sustaining of violent conflict at the micro- and macro-levels. The existing evidence suggests that variation in food production, prices, and policies are a key determinant of the conflict experiences of individuals and societies. Even though we focus on empirically robust findings, it is apparent that conflict drivers may mediated through all four pillars of food security: availability, access, stability and utilization.

In contrast to the reverse direction, most robust evidence for a causal link between food insecurity and violent conflict exists at aggregate levels. Two findings have been particularly well documented, based primarily on evidence from Africa. In urban areas, increases in food price levels raise the risk of socio-political unrest where people are more reliant on food markets than in rural areas. In rural areas, anomalies in climatic conditions increase the risk of violence and conflict, ranging from interpersonal to national intergroup levels.

Among others, three critical gaps in knowledge are apparent. First, researchers have only started to explore the causal mechanisms that elevate the risk of violent conflict through the four pillars of food security. This specifically includes an improved understanding of the role of resilience and more integration of household-level, national-level and environmental processes related to food security. While several reduced form origins have been successfully and convincingly established,

[13] For an example that demonstrates that food aid can alleviate food insecurity at the household level see, among others, Tusiime, Renard, and Smets (2013).

it is crucial to gain a better understanding of the underlying pathways, such as those originating from climatic conditions. This gap is addressed in Chapter 5.

Second, several mechanisms based on economic productivity are fairly well-theorized at both micro- and aggregate-levels, as in opportunity-cost theories. Yet, it is not well understood whether, or under which conditions, these are dominant channels as it is often claimed. In addition, a strong focus on rural sub-Saharan Africa in various literatures limits the basic generalizability of extant results to different regions and different forms of food systems and conflicts.

Third, our understanding of whether or when food-security related factors cause individuals to participate in conflict is incomplete. The empirical challenges to measure and identify such processes have already been discussed above. Theoretically, a large literature studies participation in an armed group, collective crime or collective violence. Yet, important distinctions between leaders, mobilizers and those that *are* mobilized are surprisingly absent.

These knowledge gaps constrain the capacity of policy makers and practitioners to leverage food security and resilience policies to (also) prevent and reduce conflict. A better understanding of the links from food security to conflict and peace outcomes, and which are most relevant under which conditions, is crucial to developing and testing evidence-based policies that can effectively mitigate food security-based risks of conflict ('food for peace').

2.3 Food security ↔ Violent conflict

In an ideal setup to study links in either direction, we would like to observe two identical populations, where only one is treated, and then compare outcomes between the treated and the non-treated population. As identical populations do not exist, estimation such comparisons between treated and non-treated populations are not straightforward. Essentially, the central empirical challenge is to identify plausibly comparable populations, where treatment is 'as good as random'. The main statistical threat in pinning down a causal effect in one direction is endogeneity bias.

To expose the basic issue, consider the one-way effect of conflict on food insecurity. The origin of endogeneity bias in this example is that conflict is correlated with the 'error term', i.e. an unobserved factor in a statistical model of food security. The literature suggests two principal sources of endogeneity: omitted variables and simultaneity. Omitting so-called 'confounding variables' means that a variable that is correlated with both conflict and food security is erroneously not included in the specified model of food security. Simultaneity means conflict and food insecurity may both be determined as functions of the other simultaneously. If this is the case, ordinarily estimated one-way effects will be biased.

As a real-world example of the perils of endogeneity bias, consider consumption in Afghanistan. There, a paradox emerged when consumption turned out to be *higher* in areas that had been *more* affected by conflict violence, measured by the number of casualties. One may thus conclude that conflict violence caused an increase in consumption. Yet, areas more affected by violence were also the ones that received more troop presence and aid injections. These factors are likely to be confounding variables if they are correlated with both violence and consumption. Factoring in troop presence and aid flows, it turns out that more intense violence was actually associated with lower consumption levels. This negative effect was more than offset, however, by a positive impact of troop presence and aid injections, which led to the ostensible paradox that conflict violence enhances consumption suggested by a simplistic analysis (Floreani, López-Acevedo, and Rama 2016).

Most existing empirical strategies dealing with endogeneity concerns fall into one of four categories. We now discuss the basic idea behind and examples of each category.

Selection on observables

This approach seeks to make different populations 'nearly identical' to one another in all respects except their treatment, usually after regression adjustment for observable economic, social, political and variables. The identifying assumption is that the econometrician can observe and control for all relevant confounding variables, i.e. common variables that affect treatment status and the outcome of interest (*conditional independence assumption*). Examples include simple cross-sectional analysis, matching, and synthetic control techniques.

Observe same units over time

This approach seeks to observe the same population over time, especially before and after treatment. The (basic) identifying assumption is that unobserved confounding variables are time-invariant. Examples include simple panel data analysis, panel data analysis with lagged treatment, panel data analysis with lagged outcome variables.

Exogenous variation in treatment status
This approach seeks to exploit plausibly randomized variation in the treatment of interest so that its causal impact can be evaluated. The identifying assumption is that treatment status is assigned randomly. Examples include natural experiments (assignment by nature), and controlled experiments (assignment by experimenter).

These methods exploit two main *sources* of plausibly variation of treatment status. Natural experiments, such as shocks to food security, are required to generate exogenous variation in the treatment of interest but in no other (unobserved) factor to both the outcome and treatment of interest. Controlled experiments, such as a randomized intervention related to food security, randomize treatment by construction.

For both methods, principled impact evaluation tends to be both easier and more convincing for disaggregated measures of food security and conflict. These cases allow researchers to understand the political economy of the experiment better, and identify a narrowed set of outcomes most likely to be affected to the treatment of interest (for controlled experiments this is done ex ante). The better this pre-analysis, the more promising is the assessment of causal nature of an effect, the pathways underpinning the effect and its external validity.

Exogenous variation correlated with treatment status
This approach seeks to exploit plausibly exogenous variation that is *correlated* with variation in the treatment. The identifying assumption is that the exogenous variation uncorrelated with

unobserved confounders. Examples: instrumental variables (IV), and regression discontinuity designs (RDD).

Key Limitations

In sum, various modern econometric approaches have been developed and employed to deal with concerns of statistical endogeneity affecting the relationships between food security and violent conflict. These strategies have contributed to establishing a diverse set of unidirectional effects that have a causal interpretation.

In the wake of the so-called ‘credibility revolution’ in development economics (Angrist and Pischke 2010), more reliable quantitative findings are concerned with micro-level processes, and draw on new research designs built around plausibly exogenous variation in treatment, or factors related to treatment, from natural or controlled experiments.

Among others, three critical, methodological gaps are apparent. First, less progress in terms of identification has been made at the macro-level much, compared to the micro-level, which, at least to some degree, contributed to the fact that existing macro-level results are often markedly mixed and inconclusive. At aggregate levels, randomized experiments are harder to implement and natural experiments slightly more difficult to come across. Yet, natural experiments are increasingly and convincingly employed in macroeconomic studies (Fuchs-Schündeln and Hassan 2015), and should be leveraged more in the study of the link between food security and conflict.

Second, identifying the effects of violent conflict at any level remains a central challenge. One of the reasons is that experiments where the conflict treatment itself is manipulated manually are not available. While a few innovative and sometimes `fortunate` research designs have exploited panel data in combination with plausibly exogenous conflict shocks, the toolset remains limited.

Third, identifying the effects of climatic conditions remains another central challenge, despite the wealth of recent scholarship. Like conflict, climatic conditions can (basically) not be randomized. In contrast to conflict exposure, the main statistical concern with differential exposure is less that certain units are `selected` based on their pre-treatment characteristics, but that climatic conditions often affect a myriad of factors that could lead to conflict (Dell, Jones, and Olken 2014). As more and more of such pathways are explored, widely used techniques such as using local rainfall as an instrumental variable for local economic conditions in rural areas (Miguel, Satyanath, and Sergenti 2004) have become increasingly less credible. This hence emphasizes the need to improve existing techniques to identify the effect of food security on conflict.

2.4 Conclusions

In this chapter, we survey and summarize the enormous and rapidly evolving literature on the links between food security and conflict. The review is centered around the endogeneity that characterizes the coupling between the two phenomena, and focuses on robust findings from rigorous empirical analyses.

The question of the linkage between food security and conflict has been widely and inconclusively debated across disciplines for many years, mainly using qualitative or descriptive methods. In the past few years, the increasing availability of more fine-grained and high quality data combined with modern econometric analytical approaches has produced a remarkable wealth of solid quantitative findings. These findings validate, complement and extend descriptive results that causal and substantive linkages exist between food security and violent conflict, spanning the individual, local, regional, country and global levels. Despite the impressive progress that has been made, three fundamental limitations are apparent.

First, more and better **data on and from conflict zones** is required for understanding and monitoring the full diversity, nature and interrelations of food security and violent conflict. At the national level, more reliable and informative data on either and related social, political, economic and institutional variables is required. At the sub-national level, the local nature marking many food systems and conflicts needs to be much better accounted for and measured. This particularly includes non-violent aspects of conflict and the political economy of food systems. At the micro level, better information is required how individuals and groups affect, are affected and cope with conflict and fragility, including strategies related to food security (see also Brück et al. (2016)).

Second, the most robust evidence to date exists on the `reduced-form` links between food security and violent conflict. Achieving a better understanding of the causal transmission **mechanisms** – including both economic and noneconomic channels – that underpin these links is arguably the most important next step for future work. Existing knowledge strongly suggests that food security and violent conflict are coupled through multiple pathways which may a) strongly differ across contexts and b) interact with each other and other factors.

Third, there is a dearth of reliable evidence from the **analysis of policies and interventions**. While designing, implementing and evaluating policies in conflict zones present serious practical and ethical challenges, many sub-national interventions related to food security and resilience have been successfully completed. Yet, impacts of improved food security status on conflict and peace outcomes are often assumed rather than tested rigorously, and systematic learning is rare (cf. Brück, Ferguson, Izzi, and Stojetz 2016).

These gaps emphasize the importance of understanding the context – including both the national and subnational levels – and promise high returns to research programs combining different **disciplines** and **methodologies**. Historical, psychological or ethnographic accounts, for instance, can tremendously improve the quality of quantitative data and analyses. Such accounts may offer deep institutional insights to identify exogenous sources of variation, help isolate causal mechanisms, assess external validity, and – at the micro-level – ensure sensitivity to the local context and high-quality survey data.

From a **policy perspective**, results from such approaches are required to produce informed, effective and equitable policies. Preventing the outbreak of violence, supporting individuals and groups' food security during conflict, stimulating post-conflict recovery, reacting to fluctuations in global food prices or injecting food aid, to name a few, are tall tasks in the absence of robust and context-sensitive evidence on the food-security conflict nexus at the national, sub-national and micro-levels. To illustrate, shifting agriculture to export crops has recently been promoted as "one of the most promising areas of activity in many fragile states" (WEF, 2014). Export crops are highly labor-intensive and creates employment, which could reduce conflict by decreasing the incentives of joining an armed group or increasing the state's capacity to deal with security threats and provide law and order via increased tax revenues. Yet, export crops also compete with the production of food crops which may affect food security in fragile post-war settings (Bozzoli and Brück 2009). Similarly, valuable economic resources may also enhance conflict risks, as e.g. armed group may generate funding via taxation the production of these crops. Either effect may be increased by understanding whether, when and how a shift to export crops reduces conflict thus requires high-quality data and impact analysis, based on institutional insights at the global, national and local levels.

2.5 Outlook

The following chapters address some of the existing methodological challenges and knowledge gaps.

A key challenge we will address in **Chapter 3** is how to use the available quantitative data to create meaningful clusters of conflict and food security. This chapter will also be an exercise in narrowing the scope of the analysis only to the data available from the UCDP conflict events database and the FAOSTAT food security database. Part of this exercise is exploratory, to better understand what the direct comparative relationships between the food security variables and the countries affected by different types of conflict are, as well as to set up the global and case study analyses that will use similar data to make statistical inferences about the food security-conflict nexus.

Chapter 4 provides rare quantitative evidence on the impact of conflict on food security at the country level. It uses country-year cells as the unit of analysis and exploits reliable and informative data on dietary energy supply from 106 countries across the world and across four decades. For the entire set of data points the dietary energy supply data is matched with conflict event data, which results in a rich dataset that allows to distinguish between different conflict categories, such as type of conflict, incidence and duration.

Chapters 5 and 6 provide original evidence on the micro-level mechanisms linking food security and violence conflict. **Chapter 5** combines data on climatic conditions, food production and conflict from spatially highly disaggregated cells in Ethiopia. Exploiting high-quality auxiliary data on the local economy and political exclusion, the analysis can deliver novel insights on the food security as an intermediary variable between climatic variation and various forms of conflict.

Chapter 6 integrates a monthly panel dataset of various aspects of food security at the district level and detailed cross-sectional data on food security at the household level in Ethiopia. Combining this extremely rich dataset of food security at different levels with auxiliary data on local prices, climatic conditions and conflict, this study provides a unique opportunity to shed on light on the question how climatic and conflict stresses differ, combine and interact in their impact on food security.

3. Food Security and Conflict: Analytic Framework

Introduction

This chapter derives a typology of conflict and food security, describes the relationships between these different variables, provides context for the different empirical measures of conflict and food security, and sets up the cross-national analysis and case studies that follow. The goal of this analysis is twofold. The primary goal is to provide cross-national analysis of macro patterns that can help guide the micro analysis of food security and conflict within countries. The secondary goal is to provide examples of national-level indicators of how the FAO measures food security, and the general ways that these indicators related to different forms of conflict and violence. Specifically, the analytic framework combines FAO food security data, conflict data and indicators of fragility and governance to depict broad relationships in clusters of countries facing similar challenges.

The largest differences between the conflict-affected and non-conflict affected averages are identified as the key clusters, and make up the scenario framework found in Figure 12. We selected this kind of descriptive clustering approach as a top-level way to understand how categories of conflict overlay with FAO food security data knowing that there are intervening factors which can be explored using case study and statistical methods, but that there is utility in descriptive clusters when trying to generally identify where to use different policy approaches for managing food security in conflict-affected areas. We see a general trend wherein countries affected by low-intensity conflict experience individual and household levels of food insecurity, and that as conflict intensity scales up the impacts shift from the individual level to the systemic level as measured by impacts on food price volatility and cereal import dependency.

This analysis builds on the existing work and analysis done by FAO on protracted crises, which has demonstrated a strong relationship between food insecurity and conflict-driven crises (FAO 2015a and 2016). Some key findings in the FAO's analysis were that countries facing protracted conflict within localized areas of the country may look food secure at the national level, but food insecurity and undernourishment is felt acutely in the local areas where violence takes place (FAO 2016). Another important impact that conflict has on food security is felt in the type of agricultural sector the affected country has. In countries where the agriculture sector is more automated the impacts on food prices and economic systems are more directly felt (FAO 2000). This analysis takes the findings a step farther and subdivides types of protracted crises into categories, based on state of the art conflict definitions. While this introduces some challenges in terms of interoperability of the food security and conflict category data, it shows that previous patterns are reflected in the current data and highlights areas where conflict and food security data could be co-designed to create better reflexive indicators of food security and conflict.

Because food security and food shocks are so complex and multifaceted, it is necessary to narrow the selection of types of variables. The categories for food security is based on the Food and Agriculture Organization's (FAO) food security indicators, adopted by the Committee on World

Food Security.[14] These indicators are classified into four dimensions: availability, access, stability and utilization. For this framework the five variables selected for analysis are:

- Prevalence of Undernourishment
- Cereal Import Dependency Ratio
- Share of dietary energy supply derived from cereals, roots and tubers
- Domestic Food Price Volatility
- Depth of Food Deficit

These are selected as a descriptive set of indicators since they cover health, price and production and have enough data coverage to compare with the relatively rare events of violence measured by the conflict categories.

After introducing the key food security variables, we will define the conflict categories. While all seven categories below will be analyzed, the final analytic framework clusters will only feature conflict and fragility variables that have particularly strong relationships with the food security variables.

- Low-intensity Conflict
- Interstate Conflict
- Intrastate Conflict
- Internationalized Intrastate Conflict
- One-sided Violence
- Fragility as defined by the World Bank list
- World Governance Indicators (WGI) Government Effectiveness Score

Since 1993 there has been a marked increase in intra-state and internationalized intra-state conflicts, while at the same time interstate conflict has decreased. Localized low-intensity conflict, which is a type of intrastate conflict, has also become more common since the early 1990s, leading to differences in development outcomes within countries. While not traditional war per se, this framework will also include one-sided violence where conflict actors specifically target non-combatant civilians. These categories will be defined with brief commentary on the development and food security implications associated with them. This chapter also discusses fragile states, which are countries that experience weak institutions and violence risk due to ecological, geographic and political risks. We use the World Bank's definition of fragility because this definition covers a wider range of countries than the conflict categories, and provides some insight into how weak institutions affect food security. The World Bank concept of fragility also captures macro risks in countries that are seemingly stable on the surface (for example that do not experience battle deaths).

In a next step, the food security indicators for these baskets of countries are then averaged across time and compared to the average food security indicators for countries that did not experience

[14] Available at: http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.V6tpi2Xhp74

conflict. The largest differences between the conflict-affected and non-conflict affected averages are identified as the key clusters, and make up the scenario framework found in Figure 10.

While more thorough inferential analysis will be performed in the following chapters in the cross-country analysis and the case studies, the data discussed in this chapter suggest that conflicts that are lower intensity and more localized correlate with malnourishment and dietary shortages at the individual level, while more internationalized and systemic conflicts and fragility correlate with food access risks as measured by impacts on food price volatility and cereal import dependency. By identifying macro-level patterns of how food security indicators relate to different types of violent conflict, researchers and policy makers can identify trends which can guide micro-analysis of food and conflict dynamics and, ultimately, provide the basis for interventions.

Methodological Challenges

One of the key challenges for developing empirically driven conflict-sensitive food security policy is gathering and analyzing data of good quality. With such data, it is possible to derive both descriptive insights and perhaps to conduct more detailed, causal analysis. The cross-country analysis in this chapter does the former, isolating patterns across time and between countries, which is useful for the development of policies that focus on systemic factors like food market trends and domestic food prices. Subsequent chapters will do the latter, identifying more rigorous causal relationships, which may have less general applicability. Having said that, in any given year, it may not require advance statistical methods to know which countries are going to be at the highest risk of food insecurity. For example, even though Syria does not feature in the food security data due to non-reporting, we know that there is a humanitarian crisis there and that food insecurity is a key feature of it.

There are some considerations about the goals of the databases the data come from. In conflict data, the conflict event is the basic underlying variable. It typically codes how many fatalities are observed. The process by which the event occurs is not inherent to the UCDP data. The governance data is descriptive, aggregating judgments of governance quality and capacity. These data describe the means for undertaking a governing process. The FAO food security data describes the outcomes of processes. While we derive some basic correlations and descriptive relationships between these streams of data, what comes to the fore during the data exploration is the importance of collecting data that is purpose built to measure the relationship between food security and conflict. This is a long term challenge, but what the descriptive analysis does provide is some guidance about where to look for specific categories of food security and conflict that show a descriptive or correlated relationship. One key issue is matching temporal patters in the data streams; conflicts can span long time periods making onset and offset difficult to pinpoint. These long periods of ongoing conflict usually lead to no data being reported from conflict-affected countries, so new data streams that emerge after conflict offset are in many ways epistemically new data streams, unrelated to food security indicators prior to conflict onset. This chapter aims in part to provide some basic descriptive comparisons that can support new indicator development between conflict researchers and the FAO.

Table 1: Average of food security indicators by World Bank income groups; most recent year reported to FAO

	Food Security Indicator Averages, most recent year reported by FAO				
	Prevalence of Undernourishment (2014)	Depth of Food Deficit (2014)	Percent Cereals/Roots/Tubers (2014)	Food Price Volatility Index (2014)	Cereal Import Dependency Ratio (2009)
Low-income countries	25.56%	191.71	65.21%	9.77	24.95
Lower-middle income countries	13.95%	97.88	53.64%	7.87	34.81
Upper-middle income countries	10.30%	67.55	44.50%	7.29	31.22
High-income countries	5.31%	22.16	33.17%	6.98	24.79

Disentangling the food security-conflict nexus is further complicated by the role of economic development, which shapes and is shaped by both issues and may hence be one of the potential omitted variables as argued in the previous chapter. Table 1 above indicates how food security measured by any one of four dimensions monotonously improves with rising GDP per capita levels.

To help develop new empirical methods for policy and program design at the sub-national level or in settings where conflict has rendered the state unable to gather and report data, the two national case studies of Somalia and Ethiopia provide examples of using subnational data and econometric techniques for identifying local patterns between food security and conflict. These case studies take advantage of innovations in mapping and geographically coding conflict event data, making it possible to use proxy and instrumental variables to estimate the effects of conflict on food security.

Another challenge with analyzing conflict over time is the relative rarity of events; for any given year there may only be at most a few dozen cases of measurable conflict so it is important when doing inferential analysis to control for problems with rare-event bias.

Food Security Indicators

As explained above, food security is a complex issue which does not map into a single indicator. Furthermore, different types of conflict and violence could have potential different effects on the different food security thematic areas. The five variables below were selected to test against their relationship to the conflict indicators:

- "Prevalence of Undernourishment" is the percentage of the population suffering from undernourishment; this data is reported from 1992-2014, and is a measure of the average of the previous three years' data. It is the primary food security indicator used by FAO as part of the monitoring process for Goal 1 of the MDGs.

- "Depth of Food Deficit" is an index number representing the difference between consumed calories and the necessary number of calories to reach an intake that would alleviate undernourishment.
- "Share of dietary energy supply derived from cereals, roots and tubers" represents the percentage of caloric intake made up of cereals, roots, and tubers
- "Food Price Volatility Index" represents volatility of food prices domestically from 2000-2014.
- "Cereal Import Dependency Ratio" represents the ratio of imports versus domestically produced cereals.

Some of these variables measure multi-year averages while other indicators refer to values for single years. For example, undernourishment is measured as an outcome of the three previous years' worth of data on caloric intake. Cereal import dependency ratio though is a snap shot of that year's cereal import versus domestic production, and is not impact by the previous year's score. These details are important when comparing food security data, which often measures long-term processes, with conflict data that is event-driven and is reported annually at the country level.

While there are a wide variety of food security variables listed in the FAO's set of food security indicators, these five were selected for both theoretical and functional reasons. Theoretically, these variables have been analyzed in previous research efforts and represent food-specific indicators that can be compared to conflict event data. "Prevalence of Undernourishment", "Depth of Food Deficit", and "Share of dietary energy supply from cereals, roots and tubers" are theoretically interesting starting points for developing food security-conflict policy; they provide the grounds to pose questions about how conflict affects availability and accessibility of food, and are addressed in the global analysis and case studies in the following chapters. "Food Price Volatility" and "Cereal Import Dependency" represent food security variables that have been analyzed in other studies, with a focus on how food prices and market shocks affect the outbreak of violence. These variables also allow for the descriptive analysis of different levels of types of food insecurity; different conflict categories are going to affect different aspects of food security, and the selected food security indicators can speak to individual and system-level food security.

Functionally, they were available for the time spans needed to do the basic analysis. It is recognized in conflict and development research generally that data availability and quality is often a challenge, and this challenge is compounded when looking at conflict-affected states many of whom cannot collect administrative statistics and are difficult or impossible for researchers to do surveys in. The Utilization variables often lacked enough data to make analysis possible, with well under 50% reporting rates across all countries and years. Setting those issues aside, we excluded variables if they were derivatives or subcategories of the variables mentioned above or if they were measures of infrastructure density or health factors (e.g. percentage of the population affected by anemia). Infrastructure is excluded because parties to conflict often target it for a host of tactical and strategic reasons, which may or may not influence food security. Food production variables are excluded because, like infrastructure, crops and farmland are destroyed in conflict for a variety of tactical reasons exclusive of food security (Messer and Cohen 2015).

Overall the values globally for undernourishment and food deficit have been trending downward, while there has been more global volatility related to food prices and import dependency.

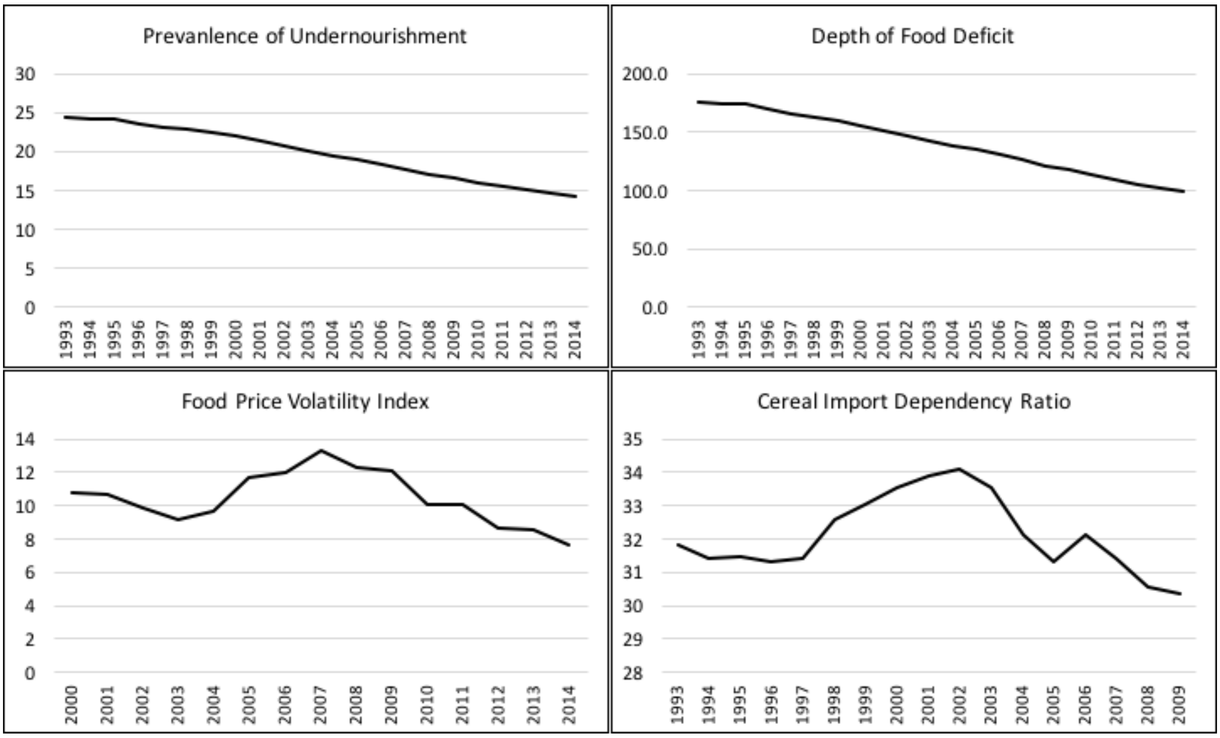


Figure 1: Depth of undernourishment is based on a percentage of population; other graphs represent indexed numbers

Variables worth tracking due to their potential impact on political and social stability are food price volatility and cereal import dependency. As argued in the previous chapter, significant changes in food prices have been observed to correlate with political instability and violence, and prices are potentially reactive to changes in import/export volumes over time.

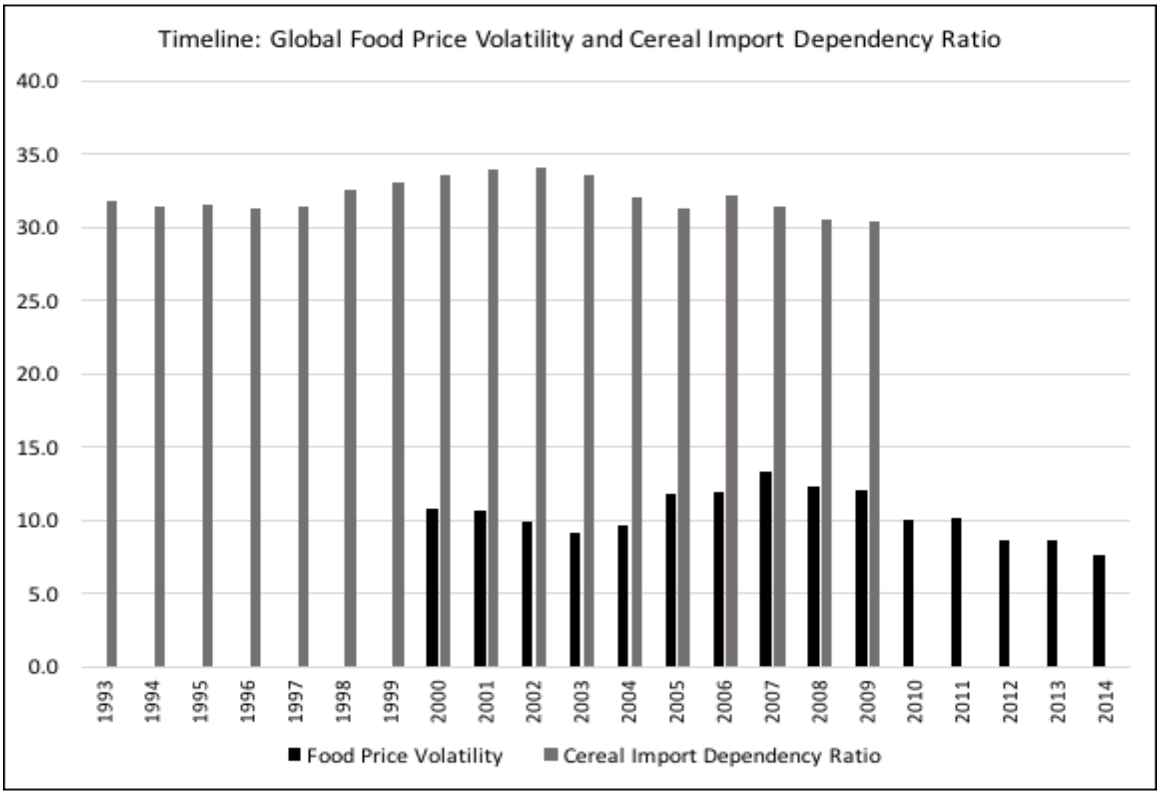


Figure 2: Food price volatility and cereal import dependency from 1993-2014

These five variables are analyzed in Table 2 further below in combination with the different types of conflict, with the aim of identifying general patterns of conflict/food security reflexivity.

Conflict and Fragility Indicators

Coding violent conflict by type is an inherently fluid exercise, since many different types of violent conflicts can take place in the same location simultaneously. To differentiate conflict types this chapter relies on the Uppsala Conflict Data Program's' definitions of different types of conflict and violence.[15] Each type will be defined, with some analysis of how food security would theoretically impact and be impacted by the dynamics of that kind of conflict. This analysis focuses on low intensity violence, interstate conflict, intrastate conflict, internationalized intrastate conflict, one-sided violence against civilians, whether a state was coded as 'fragile' by the World Bank, and on the quality of governance. Throughout this report the cross-national and national-level case studies will rely on these definitions of conflict and fragility. The variables are:

- "Low-intensity conflict" includes periods of conflict where violence or contestation is taking place at more localized levels, and at a lower intensity than a full-scale civil war.
- "Interstate conflict" is traditional country-versus-country conflict.
- "Intrastate conflict" is a conflict within a country where one side is the government and the other side is a non-state group.

[15] More information available at: http://ucdp.uu.se

- “Internationalized intrastate conflict” is defined the same way as an intrastate conflict, but includes significant involvement from other countries
- “One-sided violence” is the direct targeting of civilians by government or non-state forces
- “Fragile states” describes a state’s observed exposure to political, environmental and economic risks, which could lead to state failure or violence.
- “World Governance Indicators (WGI) Government Effectiveness Score” describes the administrative capacity of a state.

While the definitions for different categories are fairly unique to one another a problem that will be necessary to address is how often they occur simultaneously. Between 1990 and 2014 across all countries affected by any kind of conflict, there was a significant amount of overlap between one-sided violence and intrastate violence. This relationship, where militias and government forces target civilians strategically, has been observed in event data that spans 1989-2010 (Stanton 2015). There is a much lower rate of co-terminal observations of low-intensity violence with intrastate conflict, so it is possible to use low-intensity violence as an alternate categorization of one-sided violence.

The observations for low intensity conflict come from the *Managing Intrastate Low-level Conflict (MILC)* dataset (Melander et al 2009). It covers the years 1993-2004, providing enough time series to identify general patterns in food security and low intensity conflict, while providing an analytic basis for identifying case studies post-2004.

Figure 3: Number of countries affected by low-intensity conflict, 1993-2004

Burundi, Colombia, the Philippines and Senegal feature annually at a notably routine rate. For example, Senegal features in the dataset due to the ongoing low-intensity insurgency in the Casamance region; this kind of highly localized conflict could be useful in analyzing the micro-dynamics of food security and conflict at the sub-national level since the Casamance conflict only affects a very small portion of Senegal, and the intensity of the conflict varies from year to year. To explore how localized violence affects food security, the cases of Somalia and Ethiopia will be analyzed using disaggregated data on violence and food security. These two countries have experienced a mix of intrastate conflict and low-intensity conflict during the 1990s and 2000s, and both have administrative and governance features of what the Polity Project refers to as 'anocracy'. This means that both countries have governments that reflect aspects of both democracy and autocracy, so the quality of governance country-wide is rather inconsistent. For example, in Ethiopia the ethnic divisions and conflicts play out in the distribution of social development during different periods of ethnic leadership, leading to unequal distributions of state capacity and low level violence (Keller 2002; Smith 2007). The role of administrative and governance capacity will be further discussed in the section on government, conflict and capacity.

The Interstate, Intrastate and Internationalized Intrastate, all national-level categories of conflict, are based on the UCDP/PRIO Armed Conflict Dataset (Pettersson and Wallensteen 2015).

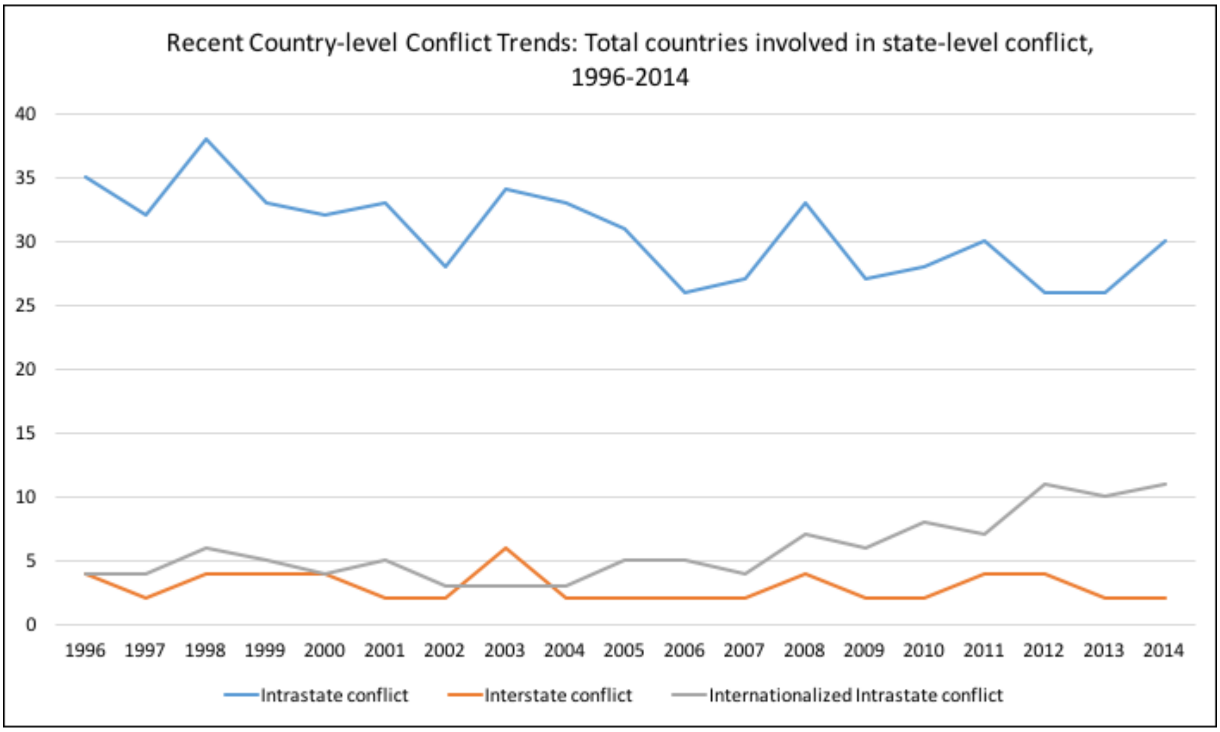


Figure 4: Total number of countries affected by different categories of state-level conflict, 1996-2014

Globally we observe a *downward trend* in the onset of new intrastate conflicts, but it is important to note that a number of countries who experience intrastate conflict continue to experience it repeatedly over long periods of time. Out of twenty-five years of observations, thirteen countries have experienced over 20 years of intrastate conflict, with Colombia experiencing intrastate conflict constantly from 1990 till 2014. Colombia is also an example of how a single type of conflict can be challenging to analyze with respect to food security and production. The conflict has varied significantly in intensity over the last 20 years, and has included many fitful efforts at peace that are starting to bear fruit.

The final category, internationalized intrastate conflict, is similar to standard intrastate conflict with the addition that one or both sides are supported by external third parties. Examples include Rwanda's support for Tutsi rebel factions in the Democratic Republic of Congo, and the United States' support of the Iraqi government's counter insurgency efforts against Al Qaeda in Iraq. This is the only state-level conflict category that is *showing an increase* in the last 18 years.

Another way to think about violence and risk is to focus on the targeting of civilians, referred to as 'one-sided violence', and the systemic risks that are inherent to fragile states. One-sided violence refers to the purposeful targeting of civilians by government or organized armed groups (Eck and Hultmann 2007). Examples include the Rwandan genocide in 1994, where there government and its affiliated militias massacred Hutu civilians and anti-government Tutsis. One-sided violence is a more common phenomenon than conflict though the number of countries that actually experience of episodes of one-sided violence remains small, at most twenty-seven in any given year, and has been decreasing in regularity since 1993. Theoretically it remains worthwhile to analyzing the relationship between food insecurity and one-sided violence though, since there could be a pattern of governments purposefully depriving a violence-targeted population of food.

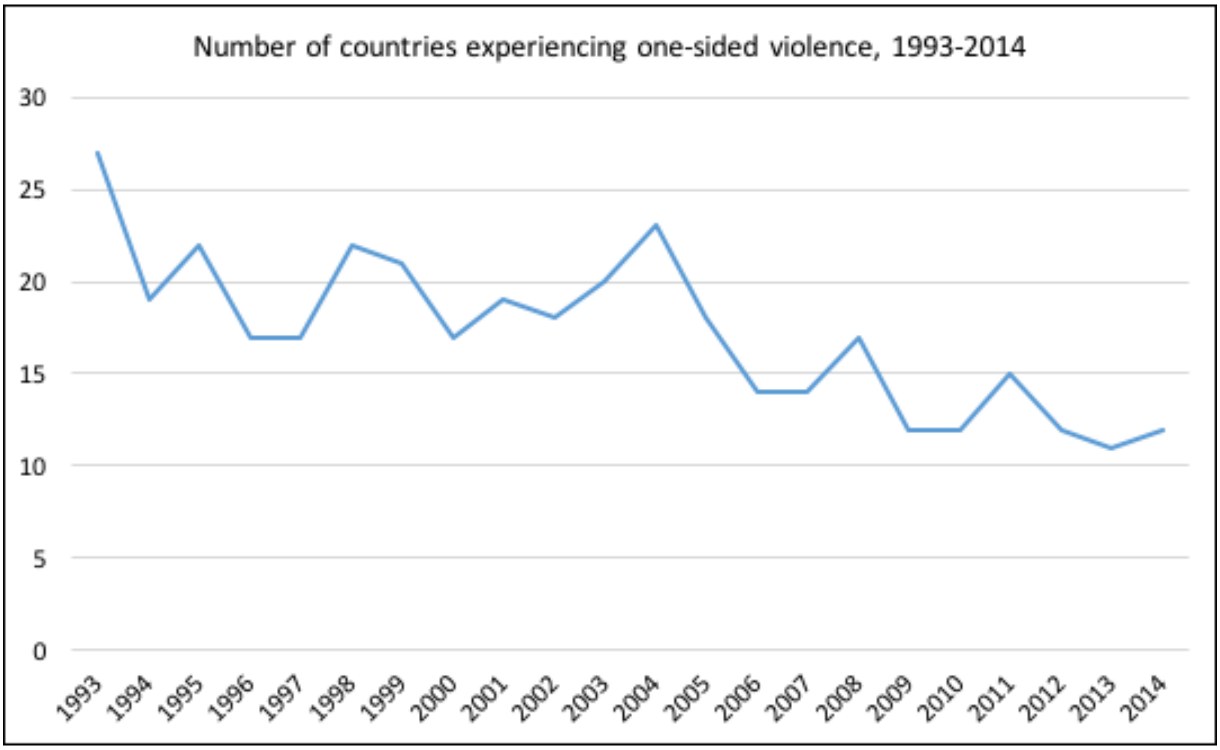


Figure 5: Number of countries experiencing one-sided violence, 1993-2014

The World Bank's integrated state fragility scores are based on overall levels of government capacity and legitimacy (World Bank 2016). They measure the capacity of the state to manage shocks and provide for the population during periods of stress. The World Bank's measure of fragility has only been in use from 2006-2014, so the timeline is relatively short for this variable.[16] This variable is theoretically important because it describes a country's institutional strength, and by extension is potential resilience to shocks that can cause outbreaks of violence. It also captures extant violence or latent political instability in the overall definition of fragility. This variable, instead of indicating the existence of a conflict event, like the other categories, provides an indication of future risk of violence.

Governance type and capacity is another aspect of fragility that is endogenous to all types of conflict and food security. This feeds into a distinct measurement problem; to report statistics on food security, a government needs to have the capacity to collect the data and report it to FAO. This problem only affects countries that are so badly affected by conflict that they lack even the basic capacity to collect data, as well as providing other administrative services. These cases are relatively rare; if we look at the Polity IV index data that codifies the type of government a country has, the number of countries that are either occupied and administered by a third party or are experiencing state failure in any given year is at most six. The early 1990s were when the most examples of pure anarchy took place, largely due to the dissolution of Yugoslavia. In the late 1990s and 2000s the average number of countries that are either externally administered or completely ungoverned ranged between 1-5. Since in any given year there were anywhere from 26-38 countries experiencing some type of conflict between 1993 and 2014, this means that there are a large number of countries that have some sort of functional government and are experiencing conflict. If we assume that government capacity is necessary for gathering data on food security and implementing food security policy, and governments can function during an ongoing conflict, then the relationship between food aid and conflict is likely to be intermediated by politics within a conflict-affected country.

Descriptive relationships between food security and conflict

Comparing food security indicators between conflict-affected and non-conflict affected countries is the starting point for identifying food security/conflict interaction typologies. This analysis is not statistical but instead relies on directly batching conflict categories by food security indicator to create what will be qualitative food security-conflict clusters. This technique was also used by Messer and Cohen in their recent analysis of food security and conflict dynamics, which drew on a wider set of categories of conflict related phenomena than we use in this analysis (Messer and Cohen 2015).

At the highest year for low-intensity conflict 17 countries were affected, while the most countries suffering intrastate conflict in any year was 25 in 1997. With 201 countries in the dataset, this means that at the highest level of intrastate conflict only 12% of total countries were impacted. While this does not make cross-country econometric analysis impossible, it indicates that case

[16] Fragility is a relatively new analytic term; the World Bank's harmonized list of fragile states is the basis for the OECD fragile states list which covers the same timeline.

studies and the micro-level analysis of the food security/conflict nexus are valuable from methodological and theoretical standpoints.

The fragility variable does not suffer from this problem to the same extent; in the sample there are between 30-35 countries coded as 'fragile' from 2006-2014. This represents 16-18% of the overall sample, and includes countries that face structural risks that may lead to violence but are not captured in the UCDP/PRIO conflict data.

Recognizing that conflict is relatively rare globally and that it tends to occur in the same places over time, Table 2 compares the averages of the five food security indicators between countries affected by the different conflict, violence and fragility categories, and countries that were unaffected. The averages represent each country's average across all observed years. For later econometric analysis the data is available as annualized panels.

Table 2 shows that:

- Low Intensity Conflict has a uniquely high relationship with high undernourishment;
- Internationalized Intrastate Conflict also has higher rates of undernourishment, as well as a higher impact on price volatility;
- Fragile States have a uniquely high level of cereal import dependency. Even when controlling for island states with unique geographic pressures, Fragile States are more exposed to global food price shocks than other countries (see Figure 7 for disaggregated averages for all Fragile States and Fragile States excluding small island states).
- Governance is a latent factor that undergirds the food security-conflict category relationships observed in Table 2. Effective administrative capacity can offset the effects of conflict on food security (see Figure 9 for data on WGI scores for conflict affected countries versus food security indicators)

This last observation is likely the result of many small island developing states being coded as fragile. Small island developing states tend to have very high cereal import dependency ratios, which can make them susceptible to food price volatility.

Table 2: Rates and indicators of food security within different conflict categories, note bolded entries show largest differences between conflict and non-conflict affected countries

Comparisons of Average Food Security Indicators: All years, All countries

		Prevalence of Undernourishment	Depth of Food Deficit	Food Price Volatility Index	Dietary eng supply cereals/roots/tubers	Cereal Import Dependency Ratio	Total countries
Low Intensity Conflict	Yes	**29.0%**	**214**	11.7	**58.06**	36.1	51
	No	**19.7%**	**136**	10.4	**49.46**	31.8	150
	Sample	**19.8%**	**141**	10.5	**49.86**	32.1	201
	Diff	**9.4%******	**78******	1.3	**8.6******	4.3	
Interstate Conflict^	Yes	23.4%	173	10.5	56.7	3.27	15
	No	19.5%	139	7.5	49.76	37.5	186
	Sample	19.8%	141	10.5	49.86	32.1	201
	Diff	3.1%	34	3.0**	6.94	34.2	
Intrastate Conflict	Yes	24.1%	177	12.4	57.08	24.2	53
	No	19.0%	134	10.2	49.05	33	148
	Sample	19.8%	141	10.5	49.86	32.1	201
	Diff	5.1%*	43*	2.2**	8.03***	8.8	
Internationalized Intrastate Conflict	Yes	27.6%	195	16.8	56.67	33.6	25
	No	19.3%	138	10.3	49.71	32.1	176
	Sample	19.8%	141	10.5	49.86	32.1	201
	Diff	8.3%	57	6.3**	6.96*	1.5	
One-sided Violence	Yes	25.3%	185	11.8	**58.75**	26.1	68
	No	18.8%	133	10.3	**48.85**	32.8	133
	Sample	19.8%	141	10.5	**49.86**	32.1	201
	Diff	6.5%**	57**	1.5*	**9.9******	6.7	
Fragile State	Yes	24.7%	183	13.2	**60.05**	41.9	51
	No	19.1%	135	10.3	**49.26**	31.6	150
	Sample	19.8%	141	10.5	**49.86**	32.1	201
	Diff	5.6%	48	2.9	**10.79******	10.3	

^ Limited number of observations; Australia, U.S., and United Kingdom are counted in this category, skewing available food security
n = 189
* = >.1, ** = >.05, *** = >.01, **** = >.001
Bold type = largest statistically significant difference between conflict and non-conflict observations

While all conflict affected states perform worse in food security (FAO 2015; Teodosijevic 2003), certain types of conflicts correlate with different types of food security. Interstate conflict, intrastate conflict, and one-sided violence do not correlate in an especially strong way with food security indicators. While countries affected by these types of violence perform less well on food security indicators than non-conflict countries, they do not perform as badly as countries affected by low-intensity conflict, internationalized intra-state conflict, or states coded by the World Bank as being fragile. The reasons for this could include a mix of a lack of food security data reporting as well as political factors in the specific countries. Many of the states experiencing interstate conflict remain relatively strong states. For example, the United States and United Kingdom are coded as experiencing interstate conflict due to their participation in the Iraq war; they are also strong, developed states that do not have systemic food security problems. While India is another example of a country involved in interstate conflict (with Pakistan) it performs relatively well on food security indicators compared to countries affected by other types of violence.

To highlight the importance of governance within conflict-affected countries we turn to the World Bank's World Governance Indicators (WGI), specifically the "Government Effectiveness" indicator. This indicator aims to describe the *capacity* of a government, with countries scored from -2.5 (worst) to 2.5 (best). Figure 9 below shows the relationship between the WGI scores for Government Effectiveness and Cereal Import Dependency Ratio, Food Price Volatility and Prevalence of Undernourishment (top to bottom). Lower scores on the Y-axis indicate greater food security, while lower scores on the X-axis indicate weaker government capacity.

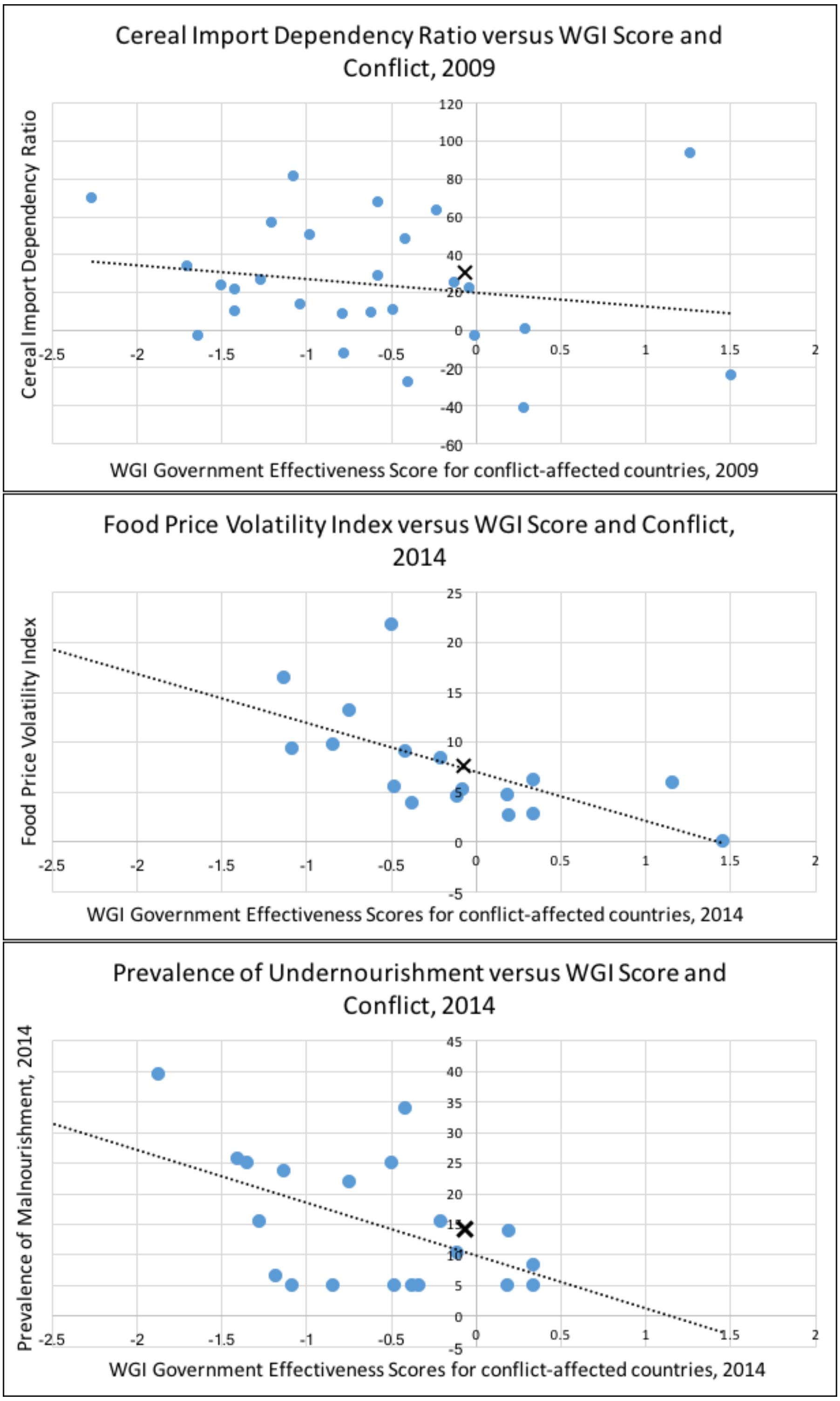


*Figure 6: Comparisons of WGI scores versus food security scores in conflict-affected countries. Top to bottom: Cereal Import Dependency Ratio, Food Price Volatility Index, Prevalence of Undernourishment. The **x** marker in the graphs is the global average for that year.*

When we break the data down into food security indicators distributed by government capacity, and then subcategorized by government performance and conflict, we see a distinct trend indicating that conflict has a negative relation with food security. As countries move from the negative to positive territory across the *x-axes* the food security indicators improve. In particular food price volatility and undernourishment decrease, even in countries affected by conflict. These descriptive statistics must be tempered with the recognition that the sample sizes are relatively small, but nonetheless are useful for thinking systematically about how conflict, governance and food security interact. From a policy perspective what this indicates is that countries with weak administrative capacity and are experiencing conflict should be prioritized for food security assistance over countries that are experiencing conflict but have intact administrative structures.

Data under-reporting is a likely concern for countries experiencing large-scale intrastate conflict. Countries experiencing large scale civil wars, such as Syria, do not report data, so the only countries reporting data who are also experiencing intrastate conflict also have retained some level of state capacity. This means that the numbers for intrastate conflict countries are likely biased positively by only representing the countries that retained strong governance despite an ongoing civil war. Better indicators of how intrastate violence affects food security are internationalized intrastate conflict, which leads to systemic political economic issues in food prices, and low-intensity conflict, which leads to localized food access and utilization challenges.

Over the time period for which there is overlapping data, countries that are experiencing low-intensity conflict have notably higher average undernourishment rates than non-conflict countries. Figures 6-8 represent the different conflict categories and food security indicators that are bolded in Figure 2, so should be treated as discrete representations, not comparative figures. The impact of localized conflict will be further explored in the Somalia and Ethiopia case studies, which analyze the subnational effects of conflict and violence on anthropometric indicators of food security. Both find that the relationship between food security and conflict is complex at the local level, and that socio-political factors have a strong impact on food security and conflict once the models control for time-invariant and national-level environmental and climate factors.

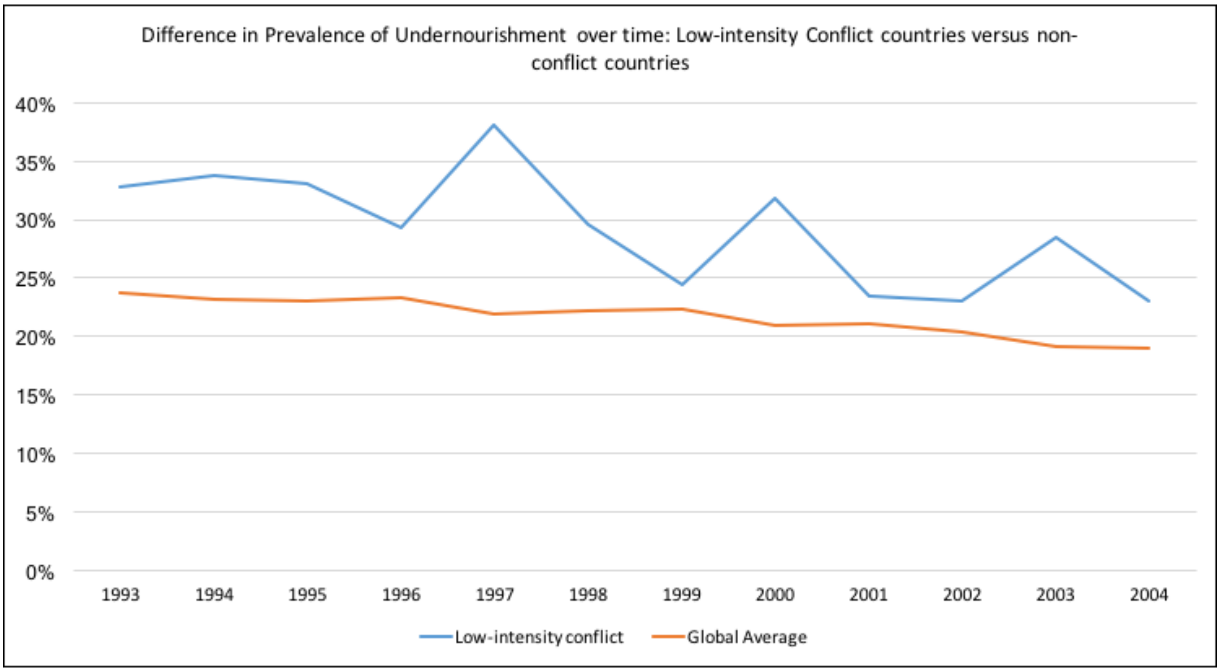


Figure 7: Difference in malnourishment over time: Low-intensity conflict countries versus global average, 1993-2004

Food prices are harder to analyze because conflict-affected countries are not as likely to be able to report nation-wide numbers. Nevertheless, Figure 6 indicates that when numbers are available food price volatility is higher in countries experiencing conflict, particularly internationalized intrastate conflict. Systemic factors in food security and conflict will be empirically explored in the cross national analysis in the next chapter.

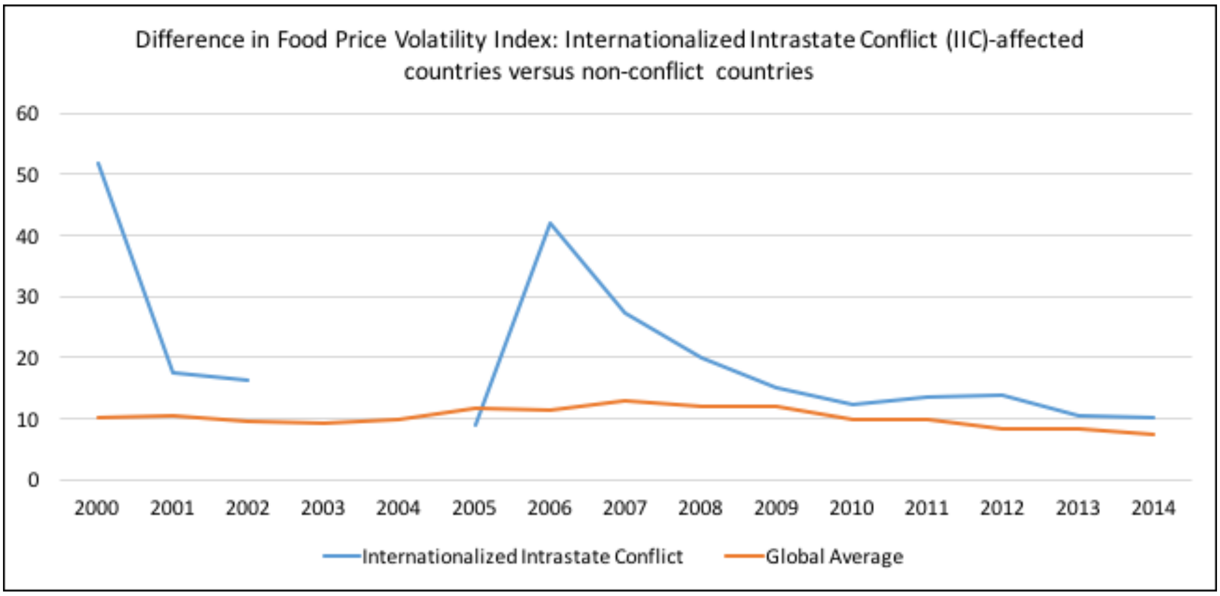


Figure 8: Different in Food Price Volatility Index: Internationalized Intrastate Violence-affected countries versus global average. NOTE: In years 2003-2004, there were no statistics reported for conflict-affected countries

The percentage of dietary energy from cereals roots and tubers is significant in countries affected by low-intensity conflict, one-sided violence and fragility. In the case of low-intensity conflict and one-sided violence, this could indicate that there are subnational variations in access to animal protein due to economic or political exclusion of groups experiencing violence; it is possible that in poorer places violence is more likely, and animal protein is harder to come by. For countries affected by fragility though, the reliance on cereals, roots, and tubers creates a higher risk of violence is there is an environmental or market shock that destabilizes food markets.

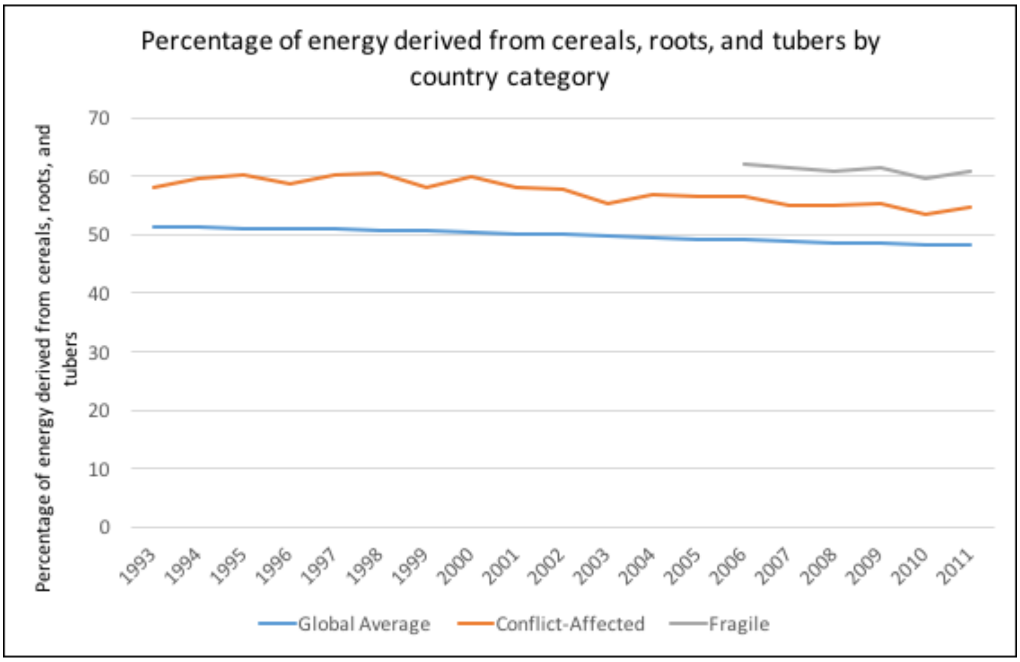


Figure 9: Percentage of daily energy intake from cereals, roots, and tubers; global average, conflict-affected states, fragile states

Fragile states are at risk of violence and conflict due to multiple factors, such as exposure to natural disasters, political instability, and geographic factors that lead to the inability to produce staple food domestically. Across cases, and specifically in Somalia, we will see how environmental and meteorological factors influence food security and conflict risks.

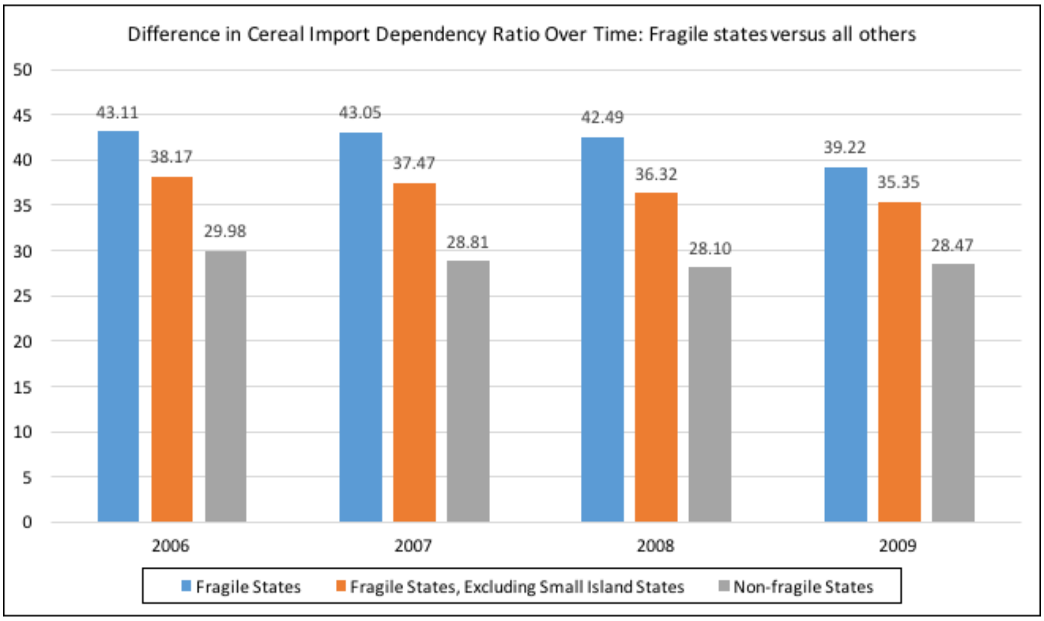


Figure 10: Difference in Cereal Import Dependency Ratio Over Time: Fragile states versus non-fragile states

Even when we remove small island states, with their unique geographic features that exacerbate reliance on cereal imports, from the analysis we see that fragile states generally are more reliant on cereal imports to meet their food security needs. This is an important dynamic to be aware of from a policy standpoint since shifts in food prices and food price instability can increase the risk of violence and conflict, which is confirmed by our cross country analysis below (van Weezel 2016). This also indicates that fragility and its relationship with food security is more than a geographic factor, and that the political and economic risks that lead to fragility may also correlate with higher risks in food markets and prices. Drawing on descriptive statistics of food security and taking the average performance of country groupings based on the World Bank's income groups (in Table 1), it is clear that economic capacity, which is heavily shaped by conflict, plays an important role in food security.

Food Security-Conflict Typology Clusters

This section of the analytical framework will derive descriptive clusters of countries based on food security and conflict risk, motivated by the work of Besley and Persson (2014) who developed a theoretically grounded approach to clustering countries by administrative capacity versus equity of access to state resources. In the typologies developed in this section, we organize by matching conflict categories to food security indicators. This means we identify countries by the type of conflict they are experiencing, then highlight their relevant food security indicators.

The critical aspect in these clusters is the importance of how governance and administrative capacity is distributed. This maps onto food security and conflict in a useful analytic way; a well-governed country could be experiencing localized conflict, but have enough capacity to still manage food security. From a policy perspective what is important to know is what kind of food security threats are being faced, and how different types of conflict and violence affect them. The role of governance is a dimension that is inherent to the typologies discussed here, but it is captured qualitatively instead of quantitatively in the clustering exercise.

To create our food security and conflict clusters we draw on the data and results in Table 2, where there is descriptive evidence that countries with *low-intensity conflicts* have a higher prevalence of undernourishment, that *internationalized* interstate conflict countries experience more undernourishment and domestic food price volatility, and that *fragile states* have a much higher cereal import dependency. The other indicators are not included in the clusters since the focus is on those categories with particularly strong food security outcomes.

This represents a range of food security-conflict relations, from the local level where there is limited systemic operation of the state, filtering up to a country being fragile and thus highly exposed to systemic shocks in global food markets. The clusters are grouped in a 3x3 grid with, representing the time spans for which there are observations of the conflict categories. The conflict categories are the leading indicator because the time span data that was collected on low-intensity conflict (1994-2004) is different than internationalized interstate conflict (1990-2014) and the World Bank's fragility measure (2006-2014). Figure 12 provides cluster descriptions of the different scenarios that can occur, with the bolded scenarios being the ones that are highlighted from Table 2. Complete listings of countries that fit into each of these categories can be found in Annexes 1-4. In Figure 12 there are three boxes highlighted that display three types of food security-conflict typologies that countries can be clustered into. These are:

Typology 1: Low-intensity, human impact cluster

This cluster of countries is generally functional at the national level, with governments that can exert enough control to set policies that keep food prices and availability generally stable. Low-intensity conflict in such a setting only impacts local areas, making it difficult to get food into the conflict affected regions. Because of this the food security problems that arise are going to be things like undernourishment or stunting; indicators that people are being affected by food insecurity even if national level indicators of food security and stability do not show any problems. One key challenge with measuring the food security-conflict relationship in this cluster is that the food security data is not sub-national, so proxy variables and GIS data is used in case studies of Ethiopia and Somalia to better understand the sub-national relationship between food security and conflict.

Typology 2: Medium to high intensity, national impact cluster

Countries that are experiencing internationalized intrastate conflict are most likely to have deficits in both human indicators of food insecurity, but also acute problems with domestic food price stability. In an internationalized intrastate conflict, the key issue is that the conflict is broad enough in scope that it prevents effective policy making and creates a policy and commercial environment that makes stable food pricing difficult. Rapid changes in food prices have been shown to lead to right and escalations of violence, as well as exacerbating ongoing conflicts.

Typology 3: Systemic risk, systemic impact cluster

These countries may or may not be in an active state of conflict, but have set of factors that make them high-risk for the outbreak of violence. They are particularly exposed to food price shocks that affect cereal imports as they have a higher rate of cereal import dependency than non-fragile states.

	Undernourishment/ Anthropometric Food Insecurity	Anthropometric Insecurity Plus Domestic Price Shocks	Exposure to supra-national price shocks
Systemic Fragility (future risks)	Administrative capacity is low, and food security is a problem of distribution instead of supply. Any potential violence would be localized and due to relative deprivation.	Administrative capacity is very low, and aside from distribution problems, policy or economic issues have led to food shortages. Risks include food riots, and urban violence.	**Type 3: Country is functional in all other ways, but at high risk of price shocks beyond its control that could lead to conflict**
Internationalized Intrastate Conflict	Conflict is lower intensity and any external participation is at a small scale; total scope of violence is not larger enough to impact national food markets.	**Type 2: Conflict is intensive enough to include external actors; impacts on population (undernourishment) and domestic food prices are noticeable.**	Scenario is likely if a civil conflict is increasingly drawing in external actors, exposing the country to wider global price issues, plus destruction of domestic crop capacity
Low-intensity conflict	**Type 1: Conflict is localized enough that impacts are not felt in nationwide food prices; only impact in on people local to the violence, felt in the form of undernourishment.**	Localized conflict leads to undernourishment in affected areas, while food price issues are more likely due to policy or administrative issues as opposed to the low intensity conflict.	Country is fragile, and has noticeable levels of localized or low intensity violence, but food security issues are only noticeable in terms of exposure to global markets.

Figure 11: Cluster typologies based on the interaction between conflict typology and food security indicators

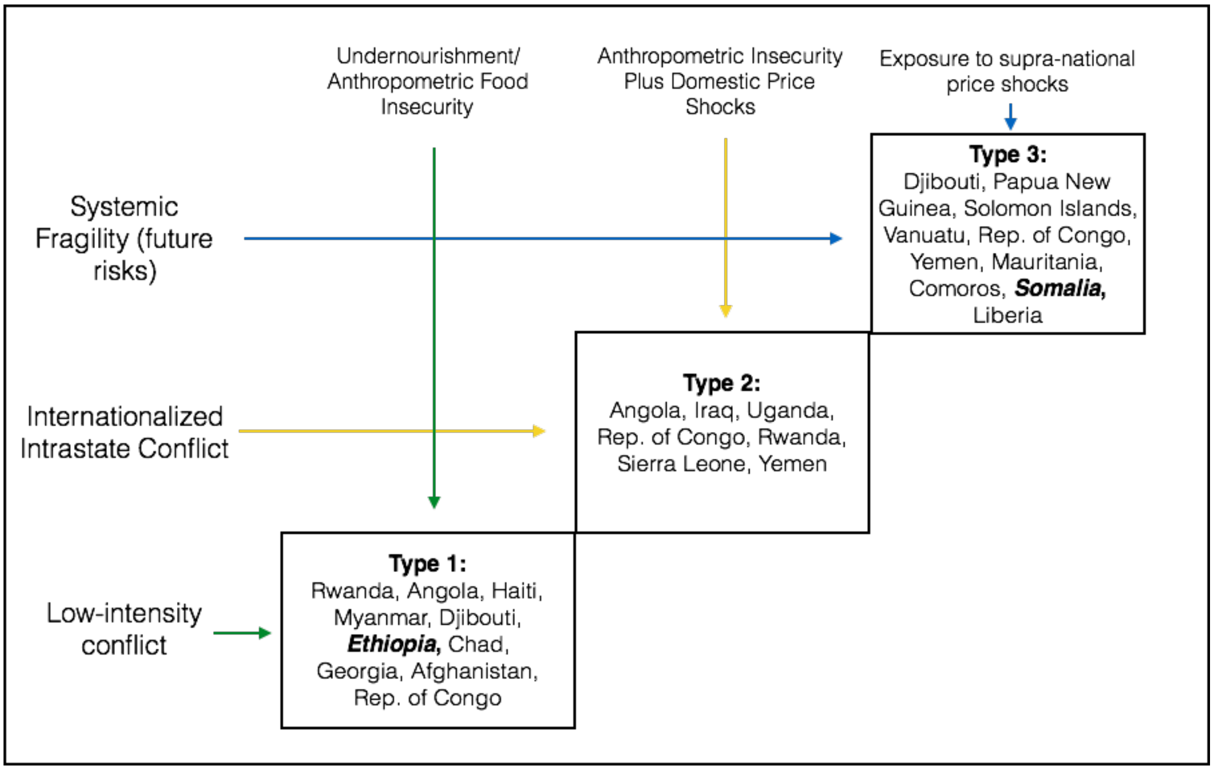


Figure 12: Ten most food insecure countries by conflict type. Note that the Type 2 cluster only contains seven countries due to food security data being unavailable for other countries affected by Internationalized Intrastate Conflict.

Outlook

The analyses that follow this chapter take the descriptive clustering and analysis a step further and explore what it looks like when scrutinized using statistical and econometric methods. We start with a global analysis of conflict events and food security, teasing out the relationships between different food security indicators and conflict. While the results show a relationship between conflict and food security, the relationship is not especially strong; it serves to indicate that granular analysis at the country and conflict-category level can show a more compelling statistical relationship between conflict and food security. This sets up the case studies of Ethiopia and Somalia, which analyze food security through the lens of a strong state that suffers from localized low intensity conflict and a weak, fragile state that has suffered from long-run varying intensity conflict. By analyzing conflict types within specific contexts using innovative sub-national data we provide confirmation of specific relationships between food security and conflict which can inform policy applications around the clusters discussed in this section.

The cross country analysis and case studies delve further into these three clusters, looking at specific examples of how conflict and food security shape each other. Our **cross-country analysis** of food security and conflict provides a framework for understanding how the clusters relate to each other. Cross-national analysis is important since supra-national and systemic factors in conflict and food distribution can have significant effects on sub-national food security and violence. The key innovation of the combined case study and cross-country analysis approach is to show how food security and conflict continually affect each other at increasing levels of disaggregation, and the shifts in what kind of food insecurity people face as the unit of analysis becomes increasingly localized.

Ethiopia falls within cluster Type 1, with ongoing low-intensity conflict. While the country is not embroiled in a civil war, there has been ongoing violence in the Ogaden region, as well as other regions outside Addis Ababa since the end of the war with Eritrea. **Somalia**, the second case study, looks at food security in a country where ongoing conflict has led to acute state fragility has been ongoing for years (Type 3). The scale of the fighting is higher than in Ethiopia, though the intensity has increased and decreased over time. Both of these case studies provide analytic value by looking at conflict intensity and food security at the sub-national level, using either proxy variables or unique household survey data on food security in combination with disaggregated data on episodes of violence in their identification strategies.

Going forward with integrated research, it will be increasingly important to define data collection and sampling methods that account for the interrelated nature of food security, as well as other development outcomes, with governance and conflict. Recognizing food security as a peacebuilding process, and conversely recognizing peacebuilding as supporting food security, can help researchers begin to develop an epistemic frame for collecting food-and-conflict data as opposed to collecting data on two separate phenomena and relying on quasi-experimental or mixed methods to fill gaps between the datasets.

4. Estimating the Eff ect of Conflict on Food Supply at the National Level

In the past two decades significant progress has been made in reducing the number of people that face severe levels of food insecurity. A recent report drafted by the Food and Agricultural Organization (FAO), the International Fund for Agricultural Development (IFAD), and the World Food Program (WFP) on the state of food insecurity in the world estimated the number of people that are undernourished at about 795 million in 2015 (FAO et al., 2015), a reduction of 196 million compared to a decade before and 216 million down from the estimate for 1991-1992. These are positive trends, and in general in terms of food security the world seems better off now than a few decades ago. Nonetheless, despite important local and regional improvements, progress has been an uneven process with some countries still facing severe difficulties in managing the food supply appropriately for their population. A stark reminder of some of the difficulties was the 2007-2008 global food price crisis that put some developing countries under severe stress (Verpoorten et al., 2013). Compared to the global trend progress has been slower in Southern Africa as well as East Asia. In some regions setbacks have been linked to political instability such as the Arab countries (Maystadt et al., 2014), while it is likely that other conflict and post-conflict countries face similar hindrances (Messer and Cohen, 2015).

There is a complex relation between food security and conflict, as conflict can affect food security via various channels while food security itself has been identified as a determinant of conflict (Pinstrup-Andersen and Shimokawa, 2008). The most direct impact of conflict on food security is the possible reduction in food availability and access as fighting has the potential to disrupt agricultural production and markets. During the course of a conflict food systems are often damaged, this includes direct damage such as the destruction of crops or arable land, but also includes the diversion of labour away from the agricultural sectors and in some cases entails a reduction 1in capital investments in the agricultural sector (Teodosijević, 2003). Most conflicts tend to be highly localised (Raleigh et al., 2010), but due to its disruptive effect on the agricultural sector is thas to potential to have a national impact. As an example, Teodosijević (2003) showed that during conflict years production levels dropped which has negative consequences for food supply levels. The incidence of violent armed conflict can lead to a reversal in the progress made and add to the number of people that face hunger FAO et al. (2015).

To gain an insight into how conflicts affect food security, this case study focuses on the link between the incidence of violent armed conflict and food supply levels as measured by the dietary energy supply (DES). We provide an analysis at the macro level using data aggregated at the country-level, covering 106 countries in Africa, Asia, and Central and South America for the period 1961-2011. The analysis shows that conflict is indeed associated with decreases in food supply levels. Conflicts with higher intensity levels, in terms of battle-related fatalities, and conflicts that involve issues about government power tend to be more disruptive as illustrated by a larger estimated reduction in the average dietary energy supply. In contrast, conflicts where the territory is the main incompatibility seemingly have little to no effect on the average dietary energy supply at the country level. Although the regression analysis shows that on average there is a negative effect, the exploratory data analysis shows that there are possibly diverging effects across countries, the result of the type of conflict. With regard to the results, we must note that although using country-level data can help provide insights into macro-level trends, a shortcoming of this approach is that some information is lost due to the level of aggregation. Using the country-year as unit of analysis means that certain sub-national effects might not be properly accounted for. We therefore would recommend in order to gain a better understanding on the conflict-food security nexus to use micro-level data for the analysis of specific mechanisms as this type of data can be used to account for these local dynamics.

Data

Measuring food security can be challenging given the myriad factors that influence the supply and demand of food and which eventually contribute to determining whether an individual has sufficient acces to food that will meet the dietary needs. At a macro level it is almost impossible to measure for each household or individual the amount of food a person consumes, which entails that we have to find a suitable alternative measure or proxy. In this study we will rely on an aggregate measure which captures the available dietary energy supply (DES) in terms of kilocalories per day per capita (kcal/day/capita). This measure is calculated by taking the total supply of food in a country available for domestic consumption and divide it by the total population. The supply of food available for domestic consumption itself is calculated by adding food imports to the national food production and subtract any food exports as well as acounting for changes in available stocks. Due to its construction this measure accounts for various channels that influence food supply in a country and thus affects food security. As an example, armed conflict in a rural area likely reduces food production due to the destruction of crops as well as diversion of labour away from the productive agricultural sector. This production loss could be compensated by increased food imports which would hamper the negative effect on food supply. Similarly, a bad harvest due to extreme weather events on one year could be compensated by available stocks.

Data on DES is taken from the FAO Food Balance Sheets (FAO Statistical Division, 2016) which is the most comprehensive global dataset available for this type of data. From this dataset we take data for 106 countries in Africa, Asia, and Central and South America covering the period 1961-2011. Some countries are missing such as the Democratic Republic of the Congo and Somalia, likely the result of data collection issues. Similarly, data is available for 2012 and 2013 but significantly fewer countries are included. Although the data source provides a comprehensive global dataset, there are some shortcomings concerning data quality since the given information are all derived statistics with the input data coming from a variety of sources which could introduce some measurement error. At a conceptual level, the largest shortcoming of the data is the fact that subsistence farming, which is an important source of food supply in developing countries, is not accounted for due to data collection challenges. Since the rural poor often depend on this type of agricultural activity for their food supply, it is likley that the country average, as provided by the data, will overestimate the DES for the rural population. Additionally, using a country average also entails that issues such as acces or inequality are omitted as the aggregated data does not account for within-country variation. Taking these shortcomings into consideration, this entails that using this data we can only provide a statistical analysis on broad patterns across countries and the empirical results should be interpreted with some caution given the discussed limitations of the data. Nonetheless, despite the shortcomings of the data it does provide a reasonable approximation of a country's food security situation (de Haen et al., 2011; Wheeler and von Braun, 2013; Blaydes and Kayser, 2011). In addition we also have to stress that good data on food security that can be used to compare the situation across countries is scarce, and that the data we use here is possibly the only dataset that provides good coverage in terms of the number of years included as well as the country selection.

Data on violent armed conflict is taken from the Armed Conflict Dataset (version 4-2016) which has a global coverage including conflicts for the period 1946-2015 (Gleditsch et al., 2002). Violent armed conflict is in this case defined as a contested incompatibility concerning government and/or territory between two parties, one of which is the government, and where armed force has lead to at least 25 battle-related deaths. Because of this definition of conflict, very small incidents of violence with fatality numbers below the 25 fatality thresholds will not be included in the dataset, nor does it include types of violence where the state isn't involved such as clashes between ethnic groups or farmer-herder violence. Due to its salience we focus on intrastate or civil conflicts. These are cases where armed force is used between the government and insurgency groups. To capture conflict incidence a dummy variable is coded for each country-year, taking value 1 if there was a conflict and 0 otherwise. We also code a dummy variable for civil wars, which are conflicts with a fatality threshold of at least 1,000 battle related deaths.

Due to data quality we can't exploit additional levels for the fatality numbers (Lacina and Gleditsch, 2005) and therefore stick to the literature standards. To reiterate conflict refers to all cases of armed force where there are at least 25 battle-related deaths, and wars where there are a 1,000 battle related deaths. We expect that civil wars will have a larger negative effect on our food supply level since wars are larger conflicts in terms of their scale of destruction, at least per definition already in terms of human fatalities. Besides exploiting these two levels of conflict intensity, we also examine if the effect of conflict on food supply levels is different if the incompatability involves government or territory. Similar to civil wars we expect that conflicts about government power will have a larger negative effect as territorial conflicts are more localised.

Exploratory data analysis

We start the analysis using data visualisation to examine whether there is some descriptive evidence for the effect of conflict on food supply, before we proceed with a more formal statistical analysis. Figure 1 presents a raw data plot of the DES data where each point represents a country-year, and where the solid black points indicate country-years with a civil war. Two locally fitted trend lines are added to the plot to indicate the trend over time. The solid black line fits the trend for all observations and illustrates that there has been a gradual increase in DES level over the years. Comparing the average DES level during the 1960s with the period since 2006 shows that there has been an increase of 488 kcal per day per capita. The red dashed line is the locally fitted trend line for the country-years with civil war (conflicts with more than 1000 battle-related fatalities in a year) and shows that over time there has been a gradual increase in DES levels too, but the average levels are lower and there is actually a downward trend in the last decade. Countries that have experienced long sustained conflicts of 10 years or more between 1961-2000, report slightly lower average DES values; 2240 (σ = 405) compared to 2367 (σ = 301) for non-conflict countries. In general though both conflict and non-conflict countries have experienced an upward trend in DES levels, although average levels are slightly lower for conflict countries.

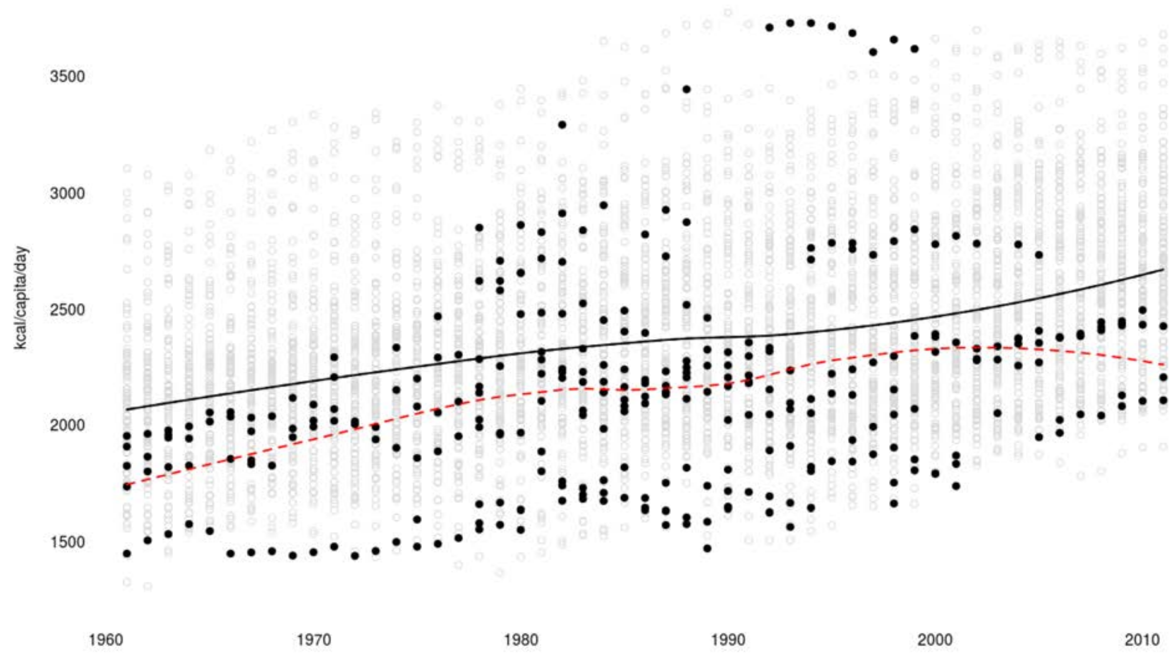


Figure 1: Dietary Energy Supply levels over time. Black points indicate country-years with civil war. The black solid line is a locally fitted annualtrend line, whereas the red dashed line is a locally fitted line for the observa-tions with civil war. Data: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2015

The figure also illustrates that a number of countries that experienced civil war have relatively high levels of food supply. Countries in this particular subset include reasonably well-developed economies such as Colombia, Israel, South Africa, and Turkey. In general though countries with a war past, such as Cambodia, Yemen, and Angola, are found below the annual trend line. Nonetheless, there are also some countries that have very low DES levels which did not experience much conflict such as Benin and Bolivia.

We split the data into individual time-series to examine the trend per country, some examples of which are given in figure 2 and 3. Figure 2 displays a number of countries that have have experienced conflict, political instability, or other socio-economic problems. The upper panel of the figure shows the two largest economies on the African continent; South Africa and Nigeria. South Africa has a reasonably well-developed economy, even after years of international embargoes during Apartheid. The data shows levels comparable to that of developed countries in Europe and the DES has remained remarkably constant over time; only a slight decrease during the 1990s. It is once more important to stress here that the data shows the country average, the situation on the ground in a rural area in Polokwane will likely be very different from that in Cape Town. In contrast to South Africa, in Nigeria the average dietary energy supply remained beneath

2,000 kcal a day, used as a benchmark here, for a long period of time. There are large fluctuations in the data throughout the 1960s and 1970s, and it is only since the 1990s that there has been an upward trend converging to the global average. This increase in food supply levels could be linked to oil revenues. Despite its agricultural potential, Nigeria depends on imports for large parts of its food supply and over the years the government has used oil revenues to keep domestic food prices low. In 2012 fuel subsidies were removed, which led amongst others to increases in food prices due to higher transport costs. Following the removal of the fuel subsidies there were nationwide protests and the army had to be deployed to contain the situation (The Economist, 2012).

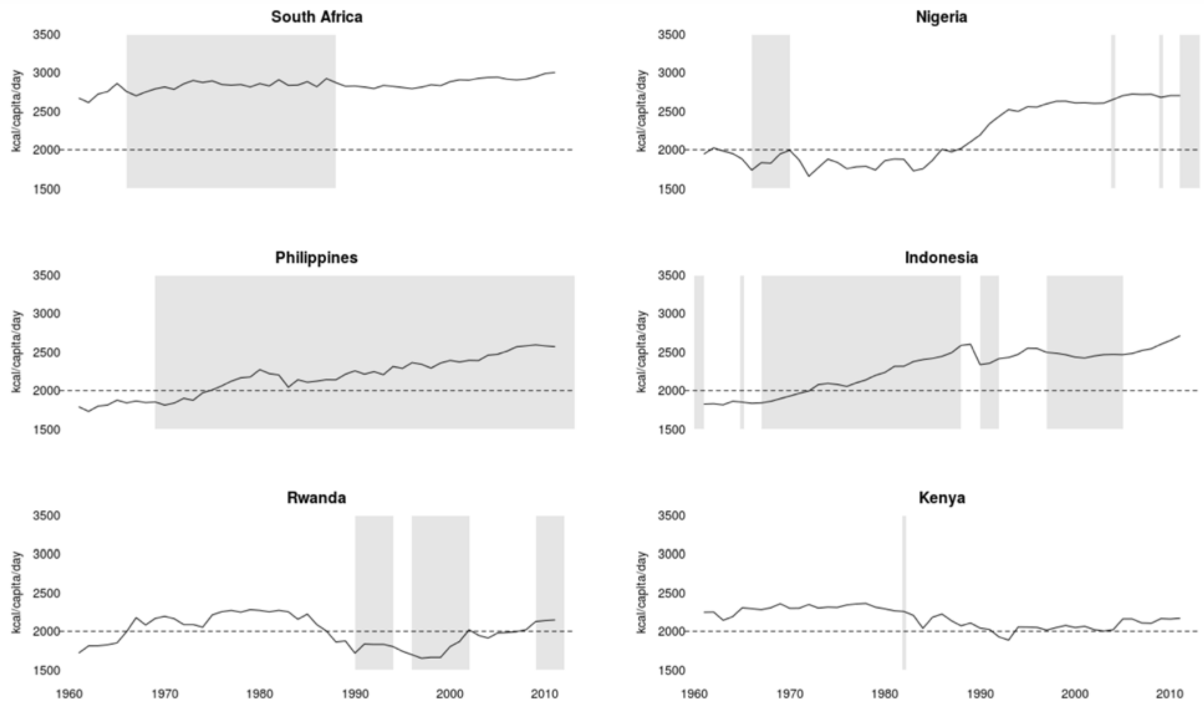


Figure 2: Time series dietary energy supply for selected countries. The grey shaded areas indicate years with violent armed conflict. Data: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2015.

The middle panel focuses on two large South-East Asian economies, the Philippines and Indonesie, two countries that both have been harried by different low-intensity conflicts over the years. These conflicts include the struggle for an autonomous state in the Mindanao in the Philippines and Timor Leste (now independent) in Indonesia. Similar to other South Asian countries, they have both experienced positive economic growth rates over the years as a result of export-oriented policies geared mainly towards raw materials. For the Philippines there is an initial increase in food supply which is followed by a rather large lull during the 1980s, a period that saw increased violence from the communist insurgency active mainly in the rural areas. The progress in Indonesia was cut short at the end of the 1980s, coinciding with the recession in the economy. A more gradual decrease in DES levels occurred in the late 1990s and lasted until about 2003. The 1998 recession caused large increases in food prices leading to riots which eventually culminated in the end of the 30-year reign of Suharto. A parallel with the 2010-2011 Arab Spring, which panned out under similar circumstance, can be made here. Following Suharto's resignation in 1998 violence continued, albeit at low intensities until 2003.

The bottom of the panel shows the data for Rwanda and Kenya, two countries in East Africa. Rwanda, a small land-locked country, has not experienced much progress in improving food supply levels in the past decades, bucking the global trend. After gaining independence there was some improvement which fizzled out relatively quickly before going into a long decline, before the start of the civil war in 1990. A further decrease followed during and after 1994 genocide, an event that has been linked to issues of land access (Verwimp, 2005). Only since the end of the Second Congo War, in which the country was involved, food supply levels have been increasing, reaching levels similar to those in the 1980s. In contrast, Kenya has been a relatively stable country except for almost endemic low-intensity violence between pastoralists in the North-Western parts of the country. However, is has suffered the severe consequences from the 1980s AIDS epidemic. Over the years food supply levels have not deviated much from the benchmark level, not following the global trend.

These individual cases provide some descriptive evidence of how conflict or instability could affect food supply levels in a country. It illustrates that there are diverging effects and that not all countries necessarily experience declines following episodes of violence. Note however that in this selection of examples all countries, except Rwanda, experienced conflict with relatively minor violence levels and often involved localised conflicts, meaning that not the entire country is necessarily affected. In contrast, figure 3 shows the data for an additional selection of countries which experienced more severe types of violent armed conflict, often affecting larger parts of the country. Angola and Mozambique (upper panel) are two former Portuguese colonies which both fought long independence wars followed by post-colonial civil wars. In Angola the independence war lasted 13 years from 1961 to 1974, which was followed by a civil war that lasted until 2002. Similarly, an independence war erupted in Mozambique in 1964 which lasted until 1974 when a cease fire was reached. Fighting resumed shortly after the 1975 negotiated independence from Portugal culminating into a civil war that lasted until 1992. Both countries exhibit DES levels consistently below the benchmark level of 2,000 kilo calories per capita per day. The figure also shows that for both countries food security levels have started to increase, since the 1990s in Mozambique after the civil war, and also during the 1990s in the later phases of the war in Angola. However, food producing areas are still affected by the conflict due to the presence of landmines which makes certain agricultural activities dangerous (Andersson et al., 1995; Unruh et al., 2003). One caveat in the analysis here is that due to the importance of subsistence agriculture in these countries the data might not be as reliable as in other cases.

The second panel from the top shows Iraq and Afghanistan, two countries that have been subject to foreign involvement in the past decade. Like many Arab countries food supply levels in Iraq followed a global upward trend, until large decrease around the time of the First Gulf War. At this point it is not clear how much of an actual decrease there actually is due to problems with measuring food supply in a country engaged in such an internationalised war such as the Gulf War. Nonetheless, ever since the Gulf War improvements in food supply have been very slow. Afghanistan has experienced a lot of volatility concerning food security (again we don't know the extend of the measurement error here). The large decrease in food supply levels coincides with the end of the Soviet occupation in 1988, with a further decline under Taliban rule. Only since the forceful removal of the Taliban with the assistance of international forces has the food situation started to improve, although regional differences exist (Souza and Jolliffe, 2013).

The development of food supply levels in Guatemala and Nicaragua have been very similar to those in Angola and Mozambique. Both Central American countries have experienced prolonged periods of conflict, especially Guatemala where the civil war lasted for more than 30 years. For Guatemala we can observe that the present situation is only slightly better compared to that during the final stages of the civil war in the early 1990s. Indeed after the peace treaty of 1996 there was a sharp decline in food supply in the years immediately following. To date, Guatemala is relatively food insecure, especially in the rural areas, with supply levels comparable to that of Iraq and Sri Lanka. Food supply levels in Nicaragua have followed a similar trend to those of Guatemala with a very sharp decrease at the end of the civil war, but things have been improving since. The average food supply level between 2009-2011 was about 88% of that of neighboring Costa Rica which didn't experience any civil war.

The lower panel shows the time-series for Liberia and Sierra Leone, two West African countries which experienced intense 8civil war through the 1990s. Both countries had moderate levels of food security to being with. Liberia seems to have had a slightly better balance but experienced rapid declines at the start of the civil war in 1989. There is a slight improvement in the situation between 1997 and 1999, when the war continues. Sierra Leone already experienced a long slump in the development of food security prior to the civil war between 1991-2002. Interestingly there is actually an increase in the dietary energy supply during the war, possibly the result of humanitarian aid although this is speculative.

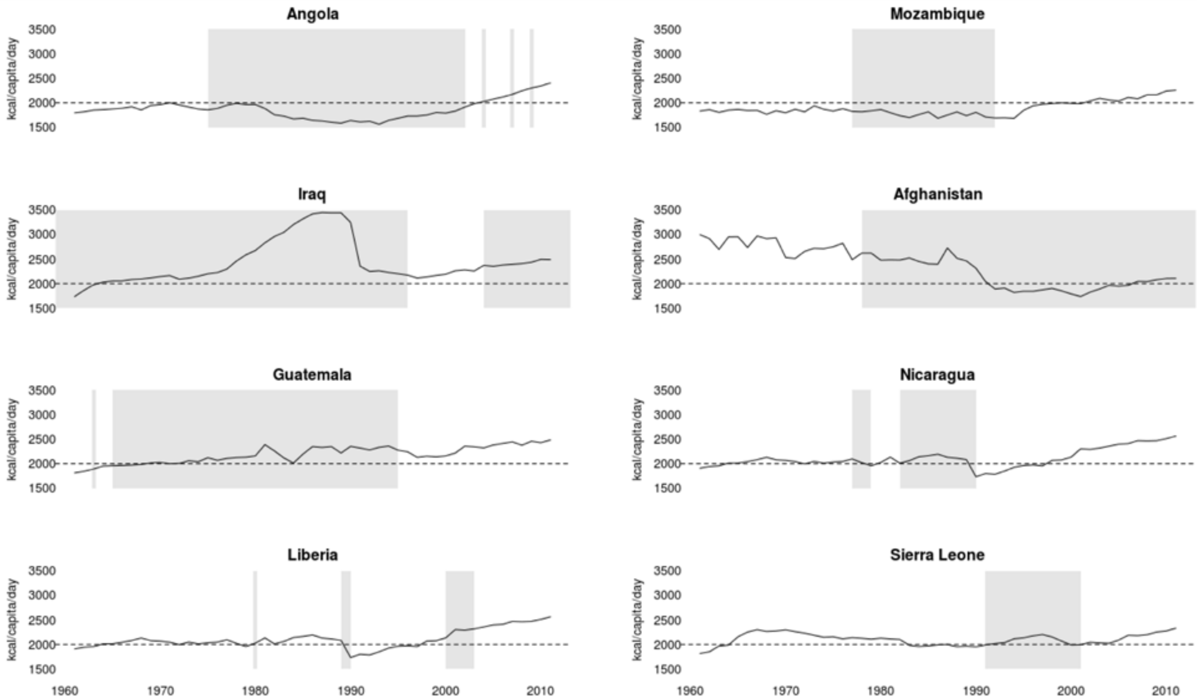


Figure 3: Time series dietary energy supply for selected countries. Thegrey shaded areas indicate years with violent armed conflict. Data: FAOFood Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2015.

We return to analyzing aggregate trends by examining the relation between the duration of peace spells and the associated levels of food supply. In this context a peace spell is simply the duration of subsequent years without a recorded conflict according to the armed conflict dataset. Exploiting the time-series variation in the data, for each unique duration length the data is aggregated to arrive at an average level of food supply. Figure 4 shows the results where the solid line indicates the average and the grey shaded area the 95% uncertainty interval. The average food supply level for zero peace years starts out relatively high which is due to the inclusion of countries like Turkey and Israel which are both coded as conflict countries for the whole period but have relatively well-developed economies and high food supply levels, pushing the average upwards. The figure further illustrates that longer peace spell durations are associated with higher food supply levels, likely the result of the fact that the upward annual trend is not interrupted. This is a very gradual process where on average each extra year of peace is associated with about a 9 kcal increase in the daily per capita dietary energy supply. Moving from one year of peace to two corresponds to an average increase of 13 kcal/day/capita, moving from 5 to 10 corresponds to a 49 kcal/day/capita increase, and going from 10 to 20 with an increase of 138 kcal/day/capita.

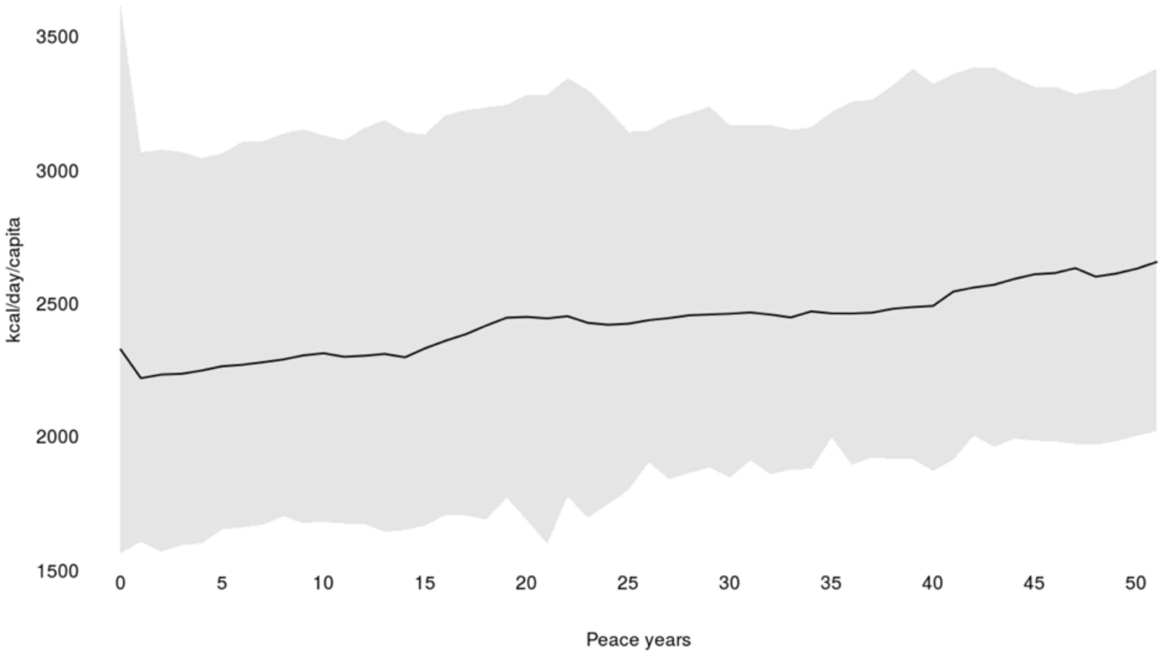


Figure 4: Length of peace years versus the average level of dietary energysupply. Solid line indicates the average and the grey shaded area the 95%uncertainty interval. Data: FAO Food Balance Sheets, UCDP/PRIO ArmedConflict Dataset v4-2015.

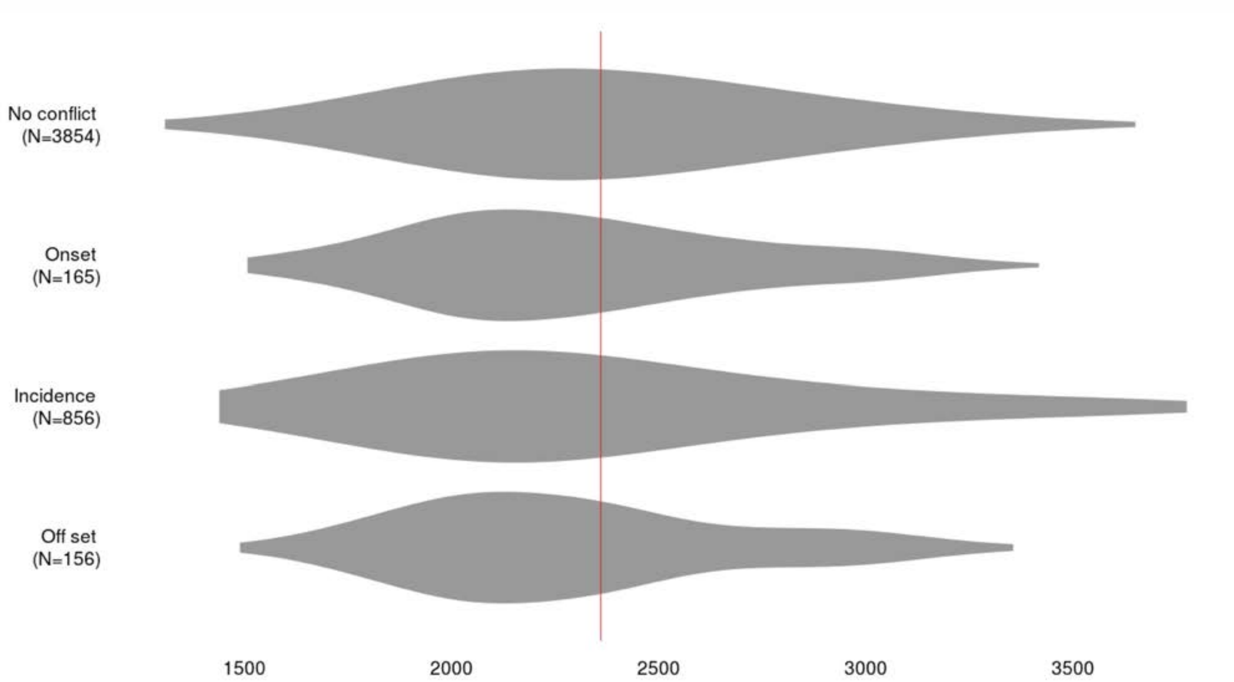
Regression analysis

We continue the analysis by fitting a model to the data to estimate the effect of conflict on food supply levels as measured by the DES. The country-year is used as unit-of-analysis which means that the results provide an insight into the correlation between conflict and food supply at the macro level, but this comes at the cost of losing subnational variation. We take this approach since there is a paucity of comparable subnational level data on food security, making a representative cross-country approach very difficult, if not impossible. Similar to the study by Blaydes and Kayser (2011) we use an Error Correction Model (ECM) to fit the data, which has the following functional form:

$$\Delta DES_{it} = \alpha_0 + \alpha_1 * DES_{t-1} + \beta_0 * \Delta Conflict_{it} + \beta 1 * Conflict_{i,t-1} \qquad (1)$$

The estimation framework links changes in the outcome variable to i) its lagged value, ii) changes in conflict status, and iii) the lagged value of the conflict indicator. The ECM is used since the data for the outcome variable exhibits, at least on average, and upward trend over time, as shown in the exploratory data analysis. Note that contrary to popular perception the variables included in an ECD model actually do not have to be cointegrated (de Boef and Keele, 2008), it is therefore appropriate to estimate the impact of conflict on food supply. The model captures the short-term effects of changes in the explanatory variable where parameter α_1 is an estimate of the error correction mechanism, i.e. the rate at which relationship returns to the equilibrium. In the main model specification the model estimates the effect of changes in conflict status conditional on past food security levels and conflict levels. Given the coding of the variables $\Delta Conflict_{it-1}$ and $Conflict_{i,t-1}$, the model accounts for four different conflict situations: i) the absence of conflict when both $\Delta Conflict_{it}$ and $Conflict_{it-1}$ t−1 are 0, ii) conflict onset when $\Delta Conflict_{it} = 1$ and $Conflict_{it-1} = 0$, iii) ongoing conflicts or conflict incidence when both $\Delta Conflict_{it}$ and $Conflict_{it-1}$ equal 1, and finally iv) conflict off set when $\Delta Conflict_{it} = 0$ and $Conflict_{it-1} = 1$.

As figure 5 shows, there are some differences in food supply levels where country-years with conflict onset or incidence have lower levels compared to peaceful years (red line indicates sample average). At the aggregate level these differences are small though as the figure illustrates. Table 1 provides additional summary statistics on the main variables.



The model is fitted using Bayesian regression which has the advantage that the estimated parameters have an intuitive probabilistic interpretation. As such the parameter estimates are given as a probability distribution which gives more information on their uncertainty compared to the uncertainty intervals of Frequentist methods which only provide a range of outcomes. The coefficients and their uncertainty interval are derived from the posterior density which is constructed using a Gibbs sampler (JAGS by Plummer (2014)) which is a Markov Chain Monte Carlo (MCMC) algorithm. Three MCMC chains are run in parallel, each with 2000 iterations, the first 500 of which are discarded as burn-in to guarantee that the estimates are taken from the posterior distribution (Brooks and Gelman, 1998; Brooks et al., 2011). In this case the coefficients and their uncertainty intervals are derived as averages across the remaining iterations. The parameters in the model are modelled using vague or non-informative priors with distribution N

(0, 10) (Gelman et al., 1995). As a result of using non-informative priors the estimated coefficients will be similar to maximum likelihood estimation. Further details on the estimation will be given as we go along.

Table 1: *Summary statistics for 106 Countries in Africa, Asia, and Centraland South America, 1962-2011 (N = 5001)*

Variable	Mean	Standard deviation	Minimum	Maximum
Δ DES	12.30	72.79	-893	628
DES_{t-1}	2348	423.37	1308	3775
Δ Conflict	0.002	0.25	-1	1
$Conflict_{t-1}$	0.20	0.40	0	1
Δ War	-0.001	0.19	-1	1
War_{t-1}	0.06	0.24	0	1

The regression results in table 2 report the mean estimated effect along with the 95% uncertainty interval given in parentheses. As a measure for the fit of the model the Root Mean Squared Error (RMSE) is included where model performance is better for smaller errors. The results shows that the different model specifications have very similar error rates, all close in size to the standard deviation of the outcome variable. Column 1 shows the main model specification according to equation 1, the change in DES is regressed on the temporal lag of DES, change in conflict status, and the conflict incidence indicator. The model here includes all types of conflict with at least 25 battle-related deaths in a year as defined by the armed conflict dataset. The results indicate that conflict onset is associated with a drop in food supply levels of 8 kcal/day/capita on average in year t and an additional 5 kcal/day/capita the year after. For both the change in conflict status and the lagged conflict indicator, the coefficient has a negative sign with a probability of 0.95. The estimated effect of the lagged value of food supply levels is very small at −0.01. Following de Boef and Keele (2008); Blaydes and Kayser (2011) we can use this coefficient to calculate the long run effect using $(\beta_0+\beta_1)/(1-\alpha_1)$ which in the case of the model in column 1 shows a further decrease of 13 kcal/capita/day. This long run effect will occur each year at progressive smaller magnitudes dictated by the error correction rate, until the effect peters out.

We proceed the analysis by making a number of adjustments to the model specifications to test the robustness of these results. A linear year trend is added (col.2) to account for a common trend over time across countries. The estimated effect of this year trend is positive, but the magnitude is very small. We also estimate the model including a variable for population growth but this doesn't alter the results (results not shown). To account for country characteristics such as income level and regime type, we use a multilevel model to estimate their effect. In the multilevel model these two variables are modelled on the constant, creating a country-specific intercept, by using their average value as is done in Danneman and Ritter (2014). There are two reasons why the annual variation in income and regime type is not exploited. First, both are slow moving meaning that there is actually very little variation over time per country. Moreover, concerning the GDP data annual estimates likely exhibit measurement error for many developing countries (Heston, 1994; Johnson et al., 2009; Jerven, 2011, 2016). Second, including the annual variation of GDP and regime type could lead to a bad control issue Angrist and Pischke (2008), where the introduced covariates could also be an outcome variable. Given that conflict is correlated with both income and regime type, this alternative approach is therefore taken.

Income is measured by GDP per capita in 10,000 dollars, with data taken from the World Development Indicators. Regime type is measured on a 1-5 scale, following Goldstone et al. (2010), where higher values correspond to more democratic regimes. The estimation shows (col.3) that the main results are robust both in terms of the direction and magnitude of the effect. Interestingly, including the additional control does not lead to a very large decrease in the error. The results also show that higher income countries and more democratic regimes are positively associated with DES, echoing the results by Blaydes and Kayser (2011).

The data from the armed conflict dataset contains information on the intensity of the conflict, making a distinction between conflicts and war, and the incompatibility of the conflict which we can exploit in our analysis. First we examine the effect of civil wars on changes in DES levels, as conflicts with higher intensity levels might have a larger impact on the food supply levels due to scale of their destruction. The estimates (col.4) indeed hint at a larger effect as there is about a threefold increase in the magnitude associated with the change of the conflict indicator, and an almost fourfold increase for the estimated effect of the conflict lag. The uncertainty associated with the estimates is also lower; both show a 100% chance of a negative effect. There is also an increase in the estimated effect for violent armed conflict about government power (col.5), although the increase here is not so severe as in the case of civil wars.

Table 2: *Predicting change in dietary energy supply in Country j, 1962-2011 (OLS). Table presents mean estimate with the 95% uncertainty interval between parentheses. Estimates are taken as the mean from 3 parallel chains with 2000 iterations each where the first 500 are discarded as burn-in, thinning rate was set to 5. Priors are N(0,10)*

Specification	Conflict **(1)**	Conflict **(2)**	Conflict **(3)**	War **(4)**	Government conflict **(5)**	Territorial conflict **(6)**
DES_{t-1}	-0.012 (-.017;-.007)	-0.015 (-0.020;-0.010)	-0.039 (-0.046;-0.031)	-0.013 (-0.017;-0.008)	-0.013 (-0.017;-0.008)	-0.012 (-0.016;-0.007)
ΔConflict	-8 (-16;1)	-8 (-16;1)	-8 (-17;0)	-25 (-36;-13)	-13 (-22;-4)	-2 (-15;12)
$Conflict_{t-1}$	-5 (-10;1)	-5 (-11;0)	-6 (-13;1)	-19 (-28;-9)	-11 (-17;-5)	5 (-2;12)
Year		0.24 (0.09;0.39)				
$GDP_{country}$			8 (-7;24)			
$Regime_{country}$			11 (-2;22)			
Intercept	41 (30;53)	42 (30;52)	73 (42;105)	43 (33;55)	44 (32;55)	40 (29;52)
RMSE	72.57	72.49	71.37	72.42	72.48	72.58
Conflict years	1005	1005	1005	295	678	457

As discussed on the data section, we indeed expected to see a larger negative effect as the geographic spread of these types of conflict is likely larger. Additionally, these types of conflicts also place a larger burden on the government to contain and counter them compared to very localized conflicts. Indeed, in contrast the estimates for conflicts concerning territorial incompatibilities seems to have a much smaller effect and the sign is negative with a probability of just 0.64. Given the fact that conflicts about territory are often highly localized it might be that violence in such areas have little impact on the national average.

For the main estimation results the coding of the variable capturing the change in conflict status assumes that there is an equal distance between the three stages of conflict: i) onset, ii) incidence, and iii) offset. However, going in and out of conflict might be quite different process so to test how this assumption might affect the results we re-estimate the model changing the variable setting conflict offset to 0. Table 3 presents the results of the estimated effect of conflict on the change in dietary energy supply. In general this recoding doesn't alter the results much in terms of the direction of the effect, but we do see some changes in the estimated magnitudes albeit slight changes. The main shift is that there is some convergence in the estimated effect between the model for all types of civil conflict and the models for civil wars and conflict about government power. The estimated effect for all types of conflict has increased moving from -8 to -10, where for the civil war model there is a reduced effect with the estimate dropping from -25 to -15. The associated uncertainty interval has also come down considerably. The estimate for conflicts about government power also decreased going from -13 to -10. For territorial conflicts we see that the estimate for the variable capturing conflict onset increased but the effect of the variable capturing lagged conflict incidence almost stays the same. We also carry out a robustness check using the length of peace-years in the model specification but the estimate is near zero.

Table 3: *Estimated coefficients for recoded conflict indicator. Table presents mean estimate with the 95% uncertainty interval between parentheses. Estimates are taken asthe mean from 3 parallel chains with 2000 iterations each where the first 500 are discarded as burn-in, thinning rate was set to 5. Priors are N (0, 10).*

Specification	*Δ Conflict*	*Conflict$_{t-1}$*
All civil conflicts	-10 (-21; 1)	-3 (-8; 2)
Civil wars	-16 (-25; -5)	-4 (-8; 2)
Government conflicts	-11 (-22; 1)	-9 (-15; -3)
Territorial conflicts	-6 (-24; 11)	5 (-1; 12)

Cross-validation

So far in our statistical analysis we have focused on analyzing the results of a model fitted to all of the available data examining the sensitivity of the estimates to changes in the variables and model specification. To further scrutinize the results, and test whether they can be generalize, we no turn our attention to cross-validation using out-of-sample data to test the predictive accuracy of the model. The main model as reported in column 1 of table 2 is re-estimated leaving out one country at a time, and subsequently we let the model predict the outcome for the left out country. The predictive error of the model is again measured by the Root Mean Squared Error, the results are shown in figure 6. In panel a of the figure the countries, indicated with a different plot symbol for each region, are plotted along the x-axis ordered progressively by the size of their RMSE indicated on the y-axis. The dashed horizontal line in the figure shows the RMSE of the model using all of the data (i.e. the one reported in col.1, table 2). In general, most countries have relatively low predictive errors with 69% of the countries having a RMSE lower than the average. Highlighting the performance for some of the countries extensively discussed in the exploratory data analysis we see that the model provides a good fit for Indonesia while Nicaragua is very close to the average. In contrast there are a number of countries which have a rather high predictive error such as Liberia. This seems to suggest that the model is not accurate in capturing the dynamics between conflict and food security in Liberia, while interestingly for Sierra Leone, a country with similar characteristics in terms of conflict, the error is much lower (106.3 versus 50.9) At the higher end of the spectrum there are a number of Arab countries such as Kuwait, Iraq, and (not indicated) the United Arab Emirates. Other countries for which the error is larger than 100 include Georgia (shown in figure), Venezuela, Panama, Cape Verde, and Cyprus.

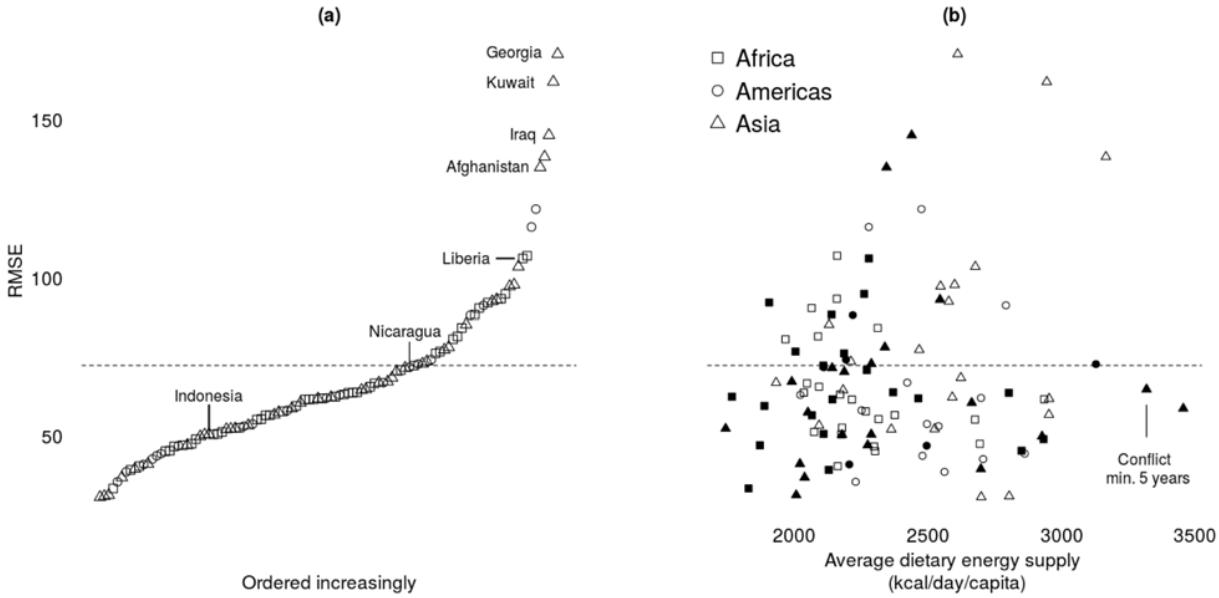


Figure 6: Results for cross-validation. The model in col.1 table 2 is cross-validated omitting one country at a time and predicting the outcome for the left out country. Figure reports the Root Mean Squared Error ordered (left)and plotted against average dietary energy supply (right).

Alternatively, panel b plots the RMSE against the average level of food supply, with countries that experienced more than 5 years of civil conflict indicated by the black dots (again the dotted line represents the average from col.1, table 2). Of interest is to see whether there is a pattern between the measured predictive error and the food supply levels, conditional on a country's conflict status. As previously highlighted, most countries with civil conflict also tend to have low food supply levels. Notable exceptions to this are Turkey, Israel (where the conflict with the Palestinians is coded as a civil war), and Argentina. There does not seem to be a bias towards prediction error for conflict countries as the proportion of countries that experienced conflict with prediction errors above average corresponds with the proportion of conflict countries in the whole sample.

We also examine the distribution of the prediction error for a number of selected regions (figure 7). The figure illustrates that this error is relatively large for West African countries. Interestingly, West Africa has made some significant progress is the past years in reducing the number of undernourished people (FAO et al., 2015). In contrast, the model seems to provide a good fit for countries in South-East Asia such as Cambodia, Myanmar, and the Philippines. The other regions show more variance in the distribution of the error, most notably in the former Soviet states. For the countries in the Middle East and North Africa, the distribution is stretched due to the high errors for Iraq, Kuwait, and the United Arab Emirates. Indeed, re-estimating the main model omitting these countries leads to slight increases in the estimated effects of conflict on the change in DES levels. The distribution for Central and South America is slightly stretched due to high errors for Panama and Venezuela, but aside from these two countries prediction errors are similar to those for South East Asia.

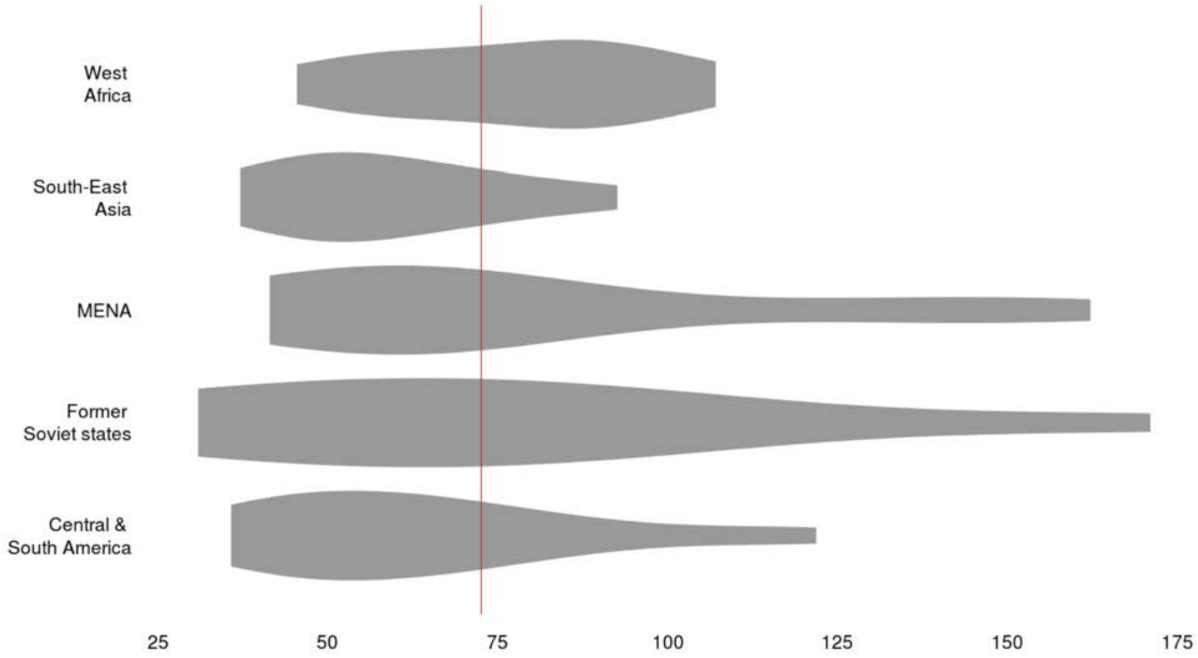


Figure 7: Distribution of the prediction error for a number of selectedregions. The red line indicates the average error (table 2, col.1).

Conclusions

This analysis examined the link between food security and conflict using data aggregated at the country level for 106 countries in the global South (Africa, Asia, and Central and South America), examining how the incidence of conflict influenced food security. Food security is in this case measured by the daily per capita dietary energy supply, while conflict is measured by an indicator signaling the onset, incidence, and offset of various types of violent armed conflict. The exploratory data analysis showed some diverging effects concerning the impact of conflict on DES levels. Some countries suffer larger setbacks, whereas some don't seem to be affected at all, at least not at an aggregate level. As the analysis points out these diverging effects are likely the results of the type of conflict that occurs in a country. Using information on the intensity and incompatibility of the conflict the regression analysis showed that civil wars and conflicts about government control have larger negative effects on food security levels compared to for instance conflicts about territory. However, there is a convergence in the magnitude of the estimated effect once we drop the assumption that there is an equal distance between conflict onset and offset. In the regression analysis conflict is associated with a negative contemporaneous effect as well as a negative long term effect. Although the magnitude of the estimated effect was not very large compared to the normal variation in the data, it could be an underestimate given that the data used to measure the dietary energy supply does not take into account subsistence agriculture. This type of agricultural activity is still vital for shares of the population in many developing countries in the sample, and they are likely to be affected given the rural character of most conflicts (Kalyvas, 2004).

The main objective was to uncover some of the macro trends concerning the nexus between food security and conflict across countries. As such, the analysis relied on the use of country-level data. Although this does provide insights into national level dynamics, due to the use of aggregated data within-country variation in both food security and conflict dynamics is missed. Not all regions of a country might experience conflict, or be affected by it. Therefore, for future research to get better a better understanding into the relation between food security and conflict a micro-level approach is recommended such as provided in the study by Souza and Jolliffe (2013) on Afghanistan for instance as well as the other work in this report. Moreover, there are a number of channels that could alleviate the impact of conflict on food security in cases where domestic production is hampered. One is the distribution of humanitarian aid which could help supplement local dietary needs, and additionally there is international trade. Indeed, many countries in the sample, specifically African countries, already import large shares of their food requirements. Although dependence on international trade might lead to other vulnerabilities, such as volatility in international food prices, it does mean that a country does not rely exclusively on domestically produced commodities for consumption. The data used for this case study does account for trade in providing additional calories, but the analysis itself did not focus on how trade, as well as humanitarian aid, might help offset some of the negative impacts (see Tusiime et al. (2013) for an example on Northern Uganda).

The following case studies take this analysis a step further we look at the distribution of low intensity violence in Ethiopia and food insecurity, and how long term violence in Somalia has affected anthropometric food security measures at the sub-national level. Using innovative new geographically disaggregated datasets that capture conflict and food security variables and proxy variables, we statistically explore the sub-national relationship between food security and violent conflict.

5. The Impact of Food Security on Conflict: Evidence from Ethiopia

Despite being among the fastest growing economies in Africa, Ethiopia has periodically experienced conflict over the past decade. The most recent chain of protests triggered by the government's plan for extending Addis Ababa's administration into Oromia resulted in an announcement of a six-month state of emergency on 8 October 2016. Recent unrests involved attacks against foreign firms and disruption of movement of goods to cities by farmers. Therefore, it seems that a combination of political and economic factors have contributed to the outbreak of recent protests.

Political power in Ethiopia has been in the hands of the Ethiopian People's Revolutionary Democratic Front (EPRDF) for more than two decades. The government has pursued a public sector investment-based development plan since the EPRDF seized power in 1991. However, GDP per capita levels has remained low and the political exclusion of opposition parties has been a source of concern in Ethiopia. While the EPRDF and its allies repeatedly obtained a majority in parliamentary elections, a lack of transparency resulted in major disputes over the election results. For example, unrests following the 2005 elections resulted in the death of nearly 200 protestors. The 2010 elections, in which EPRDF won more than 90% of the seats, was criticized by the US and EU observers as falling short of international standards.

The Ethiopian government's economic development strategy has largely relied on public sector investment. A major goal of the development plan has been to increase the share of industry versus agriculture in the country's GDP. Although high growth has been achieved following the government's development strategy, the economy remained largely reliant on agriculture, and for most of the past decade the share of industry has been lagging behind the targets. Agriculture constitutes 40% of the GDP and an estimated 75% of jobs in Ethiopia are in the agriculture sector.

As an agrarian economy Ethiopia remains highly vulnerable to severe climate conditions. Climate conditions over the past decade have not been favorable and Ethiopia has periodically experienced drought and famine. Ethiopia has three seasons namely the Kiremt (June-September), Belg (February-May) and Bega (October-January). For most parts of the country Kiremt is the main rainy season when 85% to 95% of the food crop of the country is produced (Glantz 1988). Bega season is the harvest season for agriculture when small rain might occur. The Famine Early Warning Systems Network (FEWS NET 2011) estimates a 15-20 percent decline in spring and summer rains in parts of Ethiopia since the mid-1970s. Increasing temperature at the same time has exacerbated the dryness.

Identification Method

Food insecurity can be both a cause and a consequence of human conflict. Therefore, to isolate the direction of causality of food security on conflict, rather than the reverse, we need an exogenous source of variation in food security. Otherwise the results of the regression analysis will be biased. As weather conditions such as variations in temperature and precipitation are exogenous to human conflict i.e. changes in conflict do not affect the level of precipitation or temperature, using weather variables as a proxy for food security will enable an unbiased estimation. Weather conditions have been widely used in the literature to proxy for economic factors such as the GDP particularly in agrarian economies in Africa (e.g., Maystadt and Ecker 2014, Dell et al 2012, Miguel et al. 2004).

Schlenker and Lobell (2010) provide a model to forecast yields in maize, sorghum, millet, groundnuts and cassava that are among the most important sources of calories, protein, and fat in Sub-Saharan Africa. They show that precipitation and temperature highly improve the predictive power of their model. Barrios et al (2008) show that climate, measured as changes in countrywide rainfall and temperature, has been a major determinant of agricultural production in Sub-Saharan Africa. They do not find such strong relationship in other developing countries. Therefore, the authors conclude that agriculture sector and food security in Sub-Saharan Africa is particularly sensitive to changes in climate due to geographic characteristics and agricultural practices.

Several studies have assessed the relationship between climate and food security, particularly in Ethiopia, and find a strong link. The Word Bank study of water resources in Ethiopia indicates: "Fluctuations in cereal yield levels are extremely high and closely follow patterns of rains. There is a significant correlation between national cereal yield and national average rainfall". Moreover, the study reports an even higher sensitivity to rainfall in pulses and oilseed yields. The International Food Policy Research Institute states that in Ethiopia household food security is determined by rainfall patterns, land degradation, climate change, growing populations, low agricultural investments and global market forces, particularly for smallholders. Demeke et al (2011) develop a food security index using principle component analysis and use a fixed effects instrumental variable regression model to identify determinants of households' food security in Ethiopia. They find that rainfall variability is an important determinant of food security in their sample of rural Ethiopian households. Moreover, they find a strong association between mean rainfall levels and rainfall variability and prolonged food insecurity. Dercon and Krishnan (2000) find a seasonal pattern based on the amount of rainfall in a season in adult malnutrition in a sample of 1450 Ethiopian households. Using household level data Di Falco and Veronesi (2010) show that adaptation to climate change significantly increases households' food security in Ethiopia.

Our methodological approach follows the same strand of literature. We use precipitation fluctuations as a proxy for exogenous shocks to food security as there is strong evidence of the link between climate variables such as precipitation, temperature, food availability and crop yield in agrarian economies particularly in Africa.

Figures 1-3 show the trends in some of the food security indicators in Ethiopia, as defined and measured by the Food and Agriculture Organization of the United Nations, along with changes to the average precipitation in all parts of Ethiopia. As evident from the figures in the years when precipitation peaks, food security indicators fall and vice versa. For example, in 2009 when precipitation reaches a minimum, food price volatility and cereal import dependency peak. The reverse happens in 2006 when precipitation reaches a local maximum.

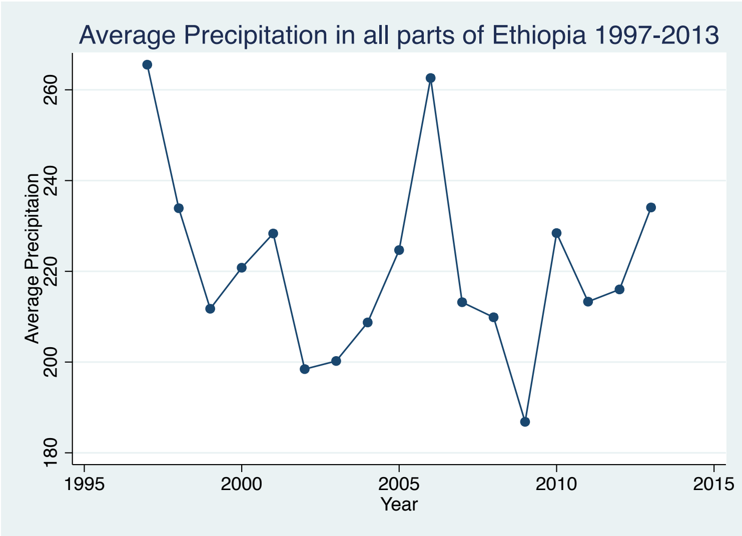


Figure 1

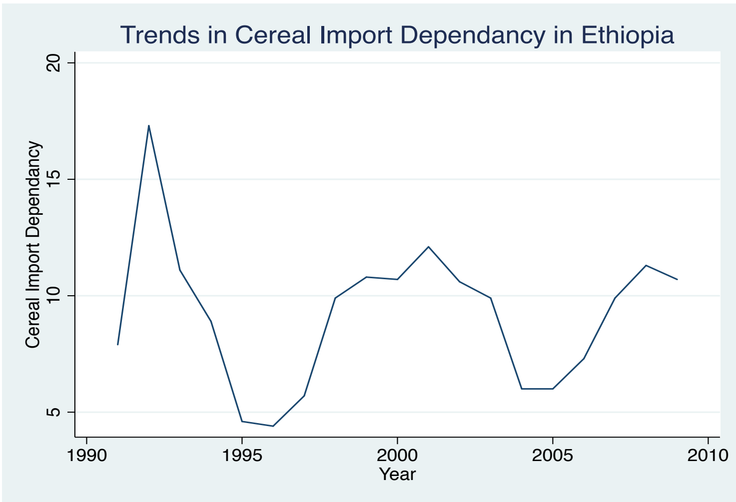


Figure 2

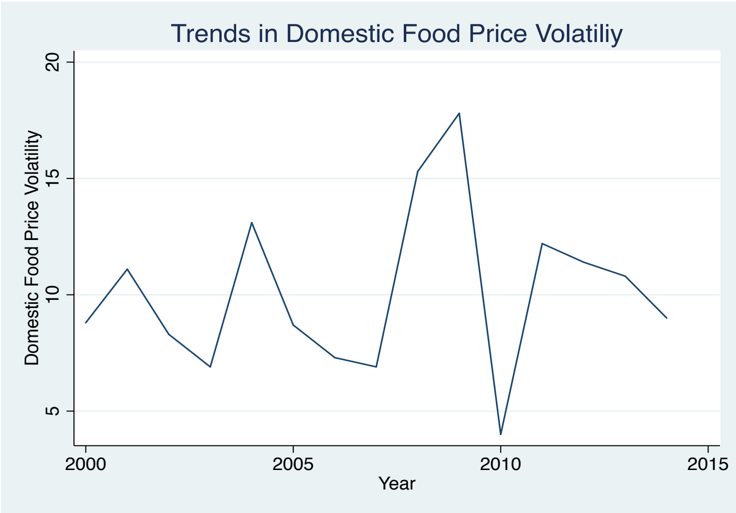


Figure 3

The link between climate variations and conflict

Security implications of climate change have been a source of concern amongst policy makers and researchers over the recent years. While there is no consensus yet amongst the policy makers on whether human conflict is affected by climate change, the idea has attracted more support over time. In the academic realm there are competing claims on whether prolonged heat and low rainfall affect the risk of conflict. Availability of geo-data at high resolution on conflict, climatic variables and some socioeconomic factors has enabled rigorous quantitative research on the subject. However, methodological differences and focus on different types of conflict have resulted in contrasting claims on the role of climate change in incidence of conflict. While some studies find a strong causal impact from climate change on conflict others explain number or onset of conflict with mere socioeconomic factors such as income and ethnic diversity.

Hsiang et al. (2013) find that a one standard deviation increase in temperature results in a four percent increase in interpersonal violence and a 14 percent increase in the frequency of intergroup violence. Hendrix et al. (2012) find a significant impact from variations in climate indicators on both low-scale and high-scale conflict in a sample of African countries. Miguel et al. (2004) use rainfall variations as a proxy for economic conditions and find a significant negative relationship between rainfall and conflict in a sample of 41 African countries. Burke et al (2009) estimates a 54% rise in armed conflict incidence by 2030 based on historical linkage between temperature and conflict and using climate model projections.

Buhaug (2010), on the other hand, finds no impact of climate variables on conflict in Africa using various model specifications. O'Loughlin et al. (2012) examine the impact of climatic factors on conflict in East Africa while controlling for country and time fixed effects. They discover little evidence for climate change driven conflict in the region, finding a small but significant positive impact of warmer than normal temperatures and a small negative impact of higher than normal precipitation on conflict.

One source of contradiction in the results is that some socioeconomic factors such as income are themselves affected by climate change. Therefore, having them as control variables in the model might absorb the impact of the climate variable and result in underestimation of the statistical significance or size of the related coefficients (Hsiang et al. 2013). Once attention is restricted to studies that account for the impact of unobserved geographical characteristics (country or subnational geographic unit fixed effect) and occasional shocks (time specific dummy variables) there is more convergence in the results. Hsiang et al. (2013) conduct a meta-analysis on 60 such quantitative studies on the impact of climate change on conflict in various fields from Economics to psychology and show that there is more agreement in the literature on the significant influence of climate change on conflict than previously thought.

An important follow up question on the subject is the mechanisms through which climate change affects conflict. It is impossible to design appropriate policy responses to the negative consequences of climate change for human conflict without identifying these mechanisms. Attempts to answer this question have usually used an instrumental variable approach. Intuitively, the estimation method tests whether climatic variables of the model such as precipitation and temperature affect conflict through affecting the selected third variable.

It is more feasible to pin down the mechanisms through which climate change affects conflict at the subnational level where the units of analysis are more homogeneous. In a case study on Somalia Maystadt and Ecker (2014) test whether climate variables affect conflict through affecting livestock prices. In the first stage of the estimation they test whether precipitation and temperature are good predictors of livestock prices. In the second stage they use the predicted livestock prices of the first stage to estimate conflict. They find livestock prices to be a credible channel for the impact of climate variations on conflict in Somalia.

While most of the studies on the link between climate variables and conflict have been done at the cross-national level, there is a deficit of case studies at the subnational level on the subject. We try to fill in this gap by focusing on subnational data on Ethiopia between 1997 and 2013. The wide range of cross-national studies provides a check on the external validity of our results. In this paper we test the below two hypotheses on Ethiopia:

Hypothesis 1: Lower average annual rainfall levels are associated with higher probability of conflict onset.

Hypothesis 2: Precipitation affects conflict through affecting total food production levels.

The test of the second hypothesis will provide evidence on whether production levels are the transmission mechanism through which precipitation affects conflict in Ethiopia. The total production variable here measures the dollar value of *total production* in the geographic units of this study. In the absence of data on food security indicators at the micro level, we use this value as an approximation of the level of *agricultural production*, which is a major determinant of food security in Ethiopia (Barrios et al 2008). This is a reasonable approximation since a large part of production in Ethiopia either directly or indirectly comes from agriculture (World Bank 2006). Our analysis would have been more informative if the exact proportion of agricultural product was known at each geographic unit of study. Nevertheless, the results of this hypothesis test can provide some insight on whether changes in precipitation affect conflict through affecting agricultural production.

Data and variables of interest

PRIO-GRID

Subnational study of conflict is less likely to suffer from the risks associated with unobserved heterogeneity among the units of analysis, as many unobserved factors such as culture and the quality of the political system are constant within a country. However, one of the challenges of such analysis is lack of data at the subnational level. PRIO-GRID collects and provides spatially disaggregated data on climate and socioeconomic variables at 0.5×0.5 decimal degrees resolution i.e. for cells of 55×55 kilometers at the equator (3025 square kilometers area). Ethiopia occupies approximately 1.1 square kilometers of land that corresponds to 372 cells with the mentioned resolution level (Tollefsen et al 2012).

The main variable of interest for the purpose of this study is the annual precipitation level. PRIO-GRID gives the yearly total amount of precipitation (in millimeters) in the cell, based on monthly meteorological statistics from the Global Precipitation Climatology Centre (Schneider et al 2015).

Moreover, we control for a number of other factors. We control for the percentage area of the cell covered by agricultural area based on ISAM-HYDE land use data (Meiyappan et al 2012). As ethnic problems are believed to be one of the drivers of conflict in Ethiopia, we include a dummy variable indicating whether at least one ethnic group is discriminated against in the cell. Data on this variable is derived from GeoEPR/EPR 2014 dataset (Vogt et al 2015). The other control variable is population as more populated areas are more likely to experience conflict. Data on population measures population size in a cell, taken from the Gridded Population of the World (Center for International Earth Science Information Network and Centro Internacional de Agricultura Tropical 2005). Population estimates have been obtained every five years since 1995. We have used linear interpolation to obtain population levels in the middle years.

In section 6.2 we test whether variations in precipitation affect conflict through affecting total production of a cell. The data on production levels indicates the gross cell product, measured in USD using purchasing-power-parity, based on the G-Econ dataset (Nordhaus 2006).[17] Total production measures have been obtained in 5-year intervals between 1990 and 2005. We have assumed a linear trend in production levels and used linear interpolation and extrapolation to obtain production levels in the missing years.

Armed Conflict Location and Event Dataset

We spatially join the PRIO-GRID data on climate and socio-economic factors with the ACLED-PRIO geo-coded data on conflict incidence (Raleigh et al 2010). The Armed Conflict Location and Event Dataset (ACLED) compiles real time data on conflict incidence based on news reports of various sources. The dataset contains information on the location, date, number of fatalities reported, actors involved in conflict and the type of their interaction. The location information

[17] http://gecon.yale.edu

provided in ACLED-PRIO shapefiles is reported based on grid cell identifiers that correspond to the grid cell identifiers used for PRIO-GRID data on precipitation, and the control variables in the model. We merged the two datasets based on the grid cell identifiers. Therefore, our analysis here is at the cell level.[18]

A total number of 1927 conflict incidences have been recorded by ACLED-PRIO in Ethiopia between 1997 and 2013. However, these conflict incidences vary from local tensions with no fatalities to major violent clashes between armed groups or between the Ethiopian military forces and protestors. Therefore, to have a clearer view of the nature of incidences, we classify conflict incidences to various types based on the actors involved and the number of fatalities. The types identified are as below:

- *Inter-State:* An event is classified as Inter-State conflict if one of the actors is the Ethiopian government, military or police forces and the other actor is a foreign government.
- *Intra-State:* An event is classified as intra-state, if one of the actors is the Ethiopian government, military or police forces of Ethiopia and the other actor is internal.
- *International Intra-State*: An Intra-State conflict where one of the actors has an ally and the ally is foreign.
- *Non-State:* An event in which no government has been involved.
- *Low intensity:* When the total number of fatalities during a year exceeds 25.

Intra-state conflict has been the most common type of conflict during 1997-2013 in Ethiopia with 530 such events taking place across all geographic units of our study. A large proportion of intra-state conflict events over this period have been clashes between the Ethiopian government and the Ogaden national liberation front, in Ogaden region bordering Somalia, and clashes with the Oromo national liberation front in the Oromia region. The other important component of this conflict type is Ethiopian government's response to protests and riots. Non-state conflict is the second most common conflict type in our sample with 228 cells experiencing such incidence between 1997 and 2013. This type of conflict mainly consists of clashes between local militia groups such as Borena and Garre ethnic militias in Oromia and Tigray and Oromo ethnic militias.

Ethiopia has frequently experienced tensions with its neighboring countries particularly Eritrea and Somalia. However, for the period of this study (1997-2013) interstate tensions have not been very prevalent in Ethiopia. ACLED has recorded 21 inter-state conflicts over this period. These include Ethiopia-Eritrea war in 1999 and continued tensions in the border with Eritrea over the following years. Figure 4 provides a map of Ethiopia showing the geographic distribution of all the conflict incidences over 1997-2013. Trends in intra-state, non-state and inter-state conflicts in 1997-2013 are illustrated in Figures 5-7.

[18] We use version 5 of the ACLED dataset here that has been last updated in 2014. Therefore, any possible changes to the administrative boundaries over the period before 2014 have been counted for in our data.

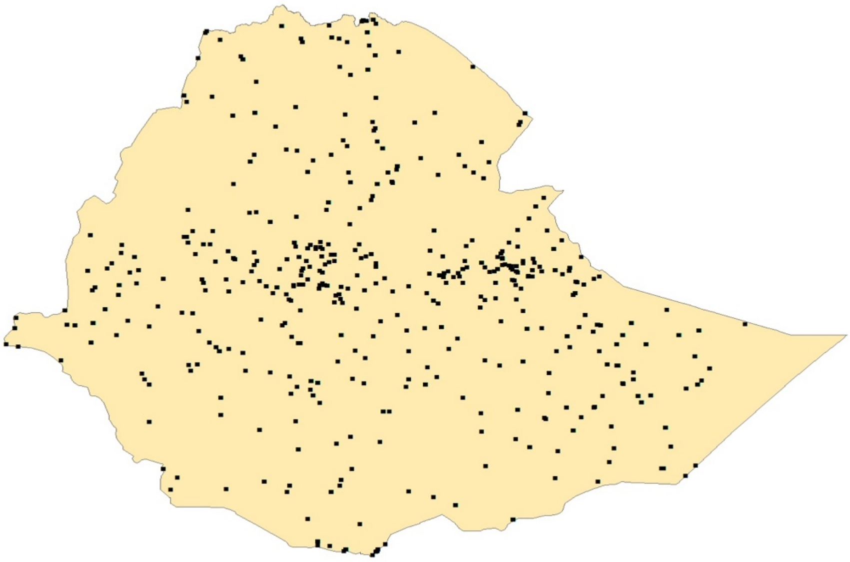


Figure 4: Geographic Distribution of Conflict Incidences in Ethiopia 1997-2015

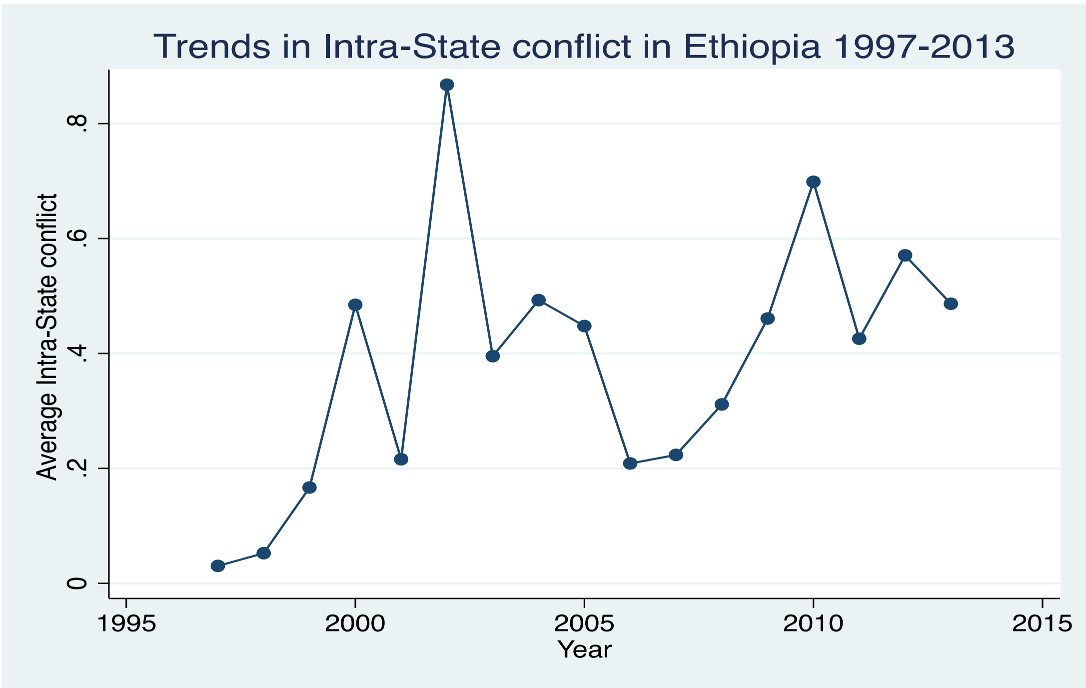


Figure 5

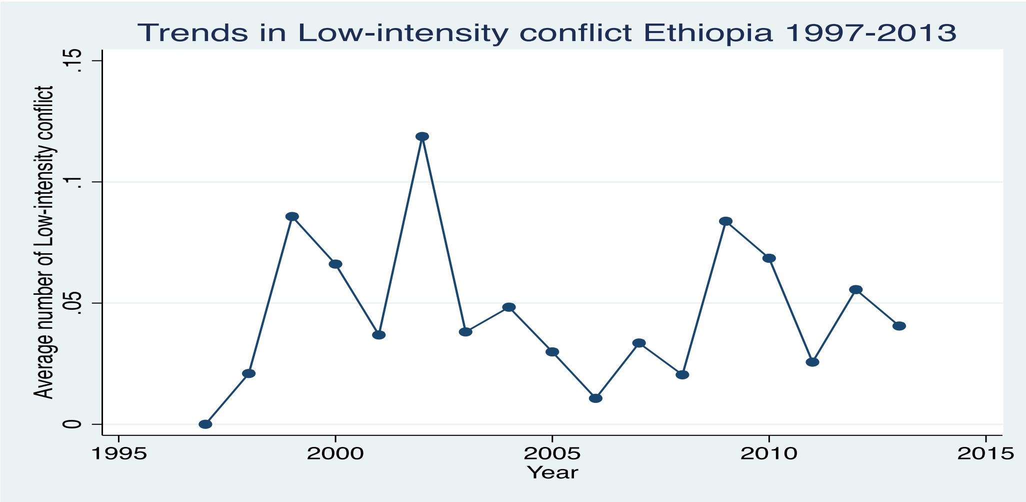


Figure 6

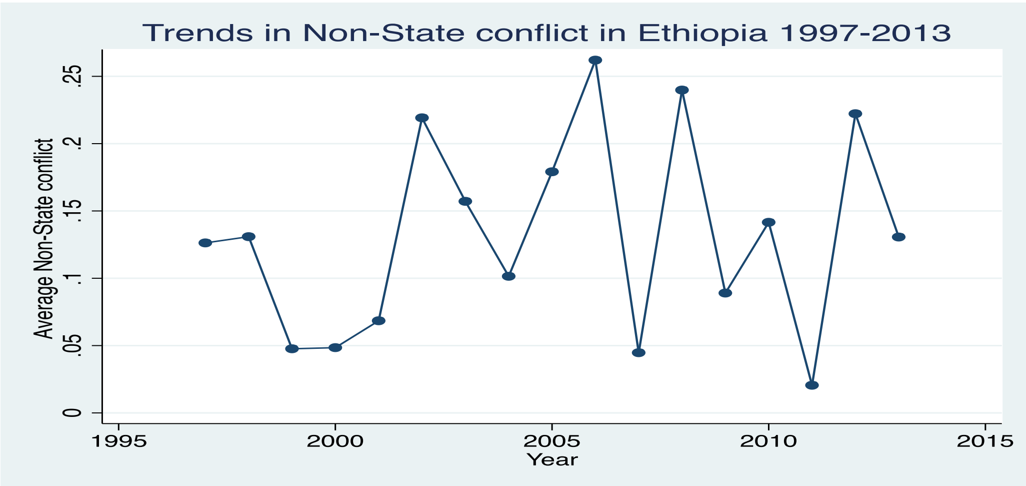


Figure 7

Descriptive statistics of the data

The time span of our study is 1997 to 2013, which is the longest period for which data on conflict, climate and socioeconomic factors is available. The time unit of analysis is years. Therefore, the final dataset is a panel of yearly information on conflict, precipitation and control variables at the cell level. Descriptive statistics of the variables in presented in Table 1:

Table 1: Descriptive Statistics of the variables:

Variable	Observations	Mean	Std. Dev.	Min	Max
%Agricultural Land	3440	12.29549	12.4821	0	76.098
Population	3440	201827.6	271100.5	1942.008	2713806
Production	3440	0.1300958	0.1756596	0.0007176	1.26335
Conflict Count	3461	0.5564866	2.05349	0	32
Precipitation	3440	220.7923	117.4407	18.1825	560.1375

Case Control Sampling

Considering the very high resolution of our data (55km×55km cells) it is likely that no conflict is reported in a large proportion of the cells. In fact, conflict onset has only been reported in around 10% of the cells in our sample. Therefore, we face the problem of "rare events" and "excess number of zeros" (non-onset cells) in our sample. Estimation of rare events such as conflict with usual binary response methods such as logit can be problematic as these methods are likely to underestimate the probability of rare events. A more efficient sampling design that enables valid inferences in such cases is sampling of all available events and a fraction of nonevents (King and Zeng 2001). This sampling strategy is widely used in medicine to study determinants of rare events such as being diagnosed with cancer where the diseased individuals (cases) are rare compared to a sample of non-diseased individuals from the population (controls).

The other problem that might arise in using high-resolution geo-coded data on conflict is the possibility of spatial correlation of observations in nearby cells. In a study of the impact of income on conflict, Buhaug et al. (2011) use a case control logit method to resolve both of these problems. The method compares the conflict onset cells with a sub-sample of non-onset cells. Spatial correlation decays as the distance between two cells increases.[19] While the non-onset zeros are chosen randomly from all cells it is unlikely that neighboring or close by cells appear in the case control sample. Therefore, the case control sample is less likely to exhibit spatial correlation. However, this claim can be challenged as the case control sample contains all the onset cells. Therefore, it is equally likely to have neighboring or close by onset cells in the original data and the case control sample.

It is recommended in case control analysis that the ratio of controls to cases in the final sample is 4:1. Following this approach and considering the distribution of onset and non-onset cells in our

[19] Buhaug et al. (2011) show that in their data the correlation reaches zero for cells that are 1000km or more apart

original sample, our case control sample will consist of approximately 55% of the observations in the original sample.[20] The large size of the case control sample relative to the original sample has the advantage of providing more consistent estimates in repeated sampling. We repeated our analysis with five more case control samples and the results (the sign and significance of coefficients on variables of interest) remained unchanged. On the downside, while more than half of the original cells are sampled it is unlikely that the problem of spatial correlation is resolved. However, the case control method resolves the rare event problem and therefore, we continue our analysis on case control samples. Where the option is available on the software we use grid-clustered standard errors to account for the possibility of spatial correlation.

Hypotheses Tests

Impact of precipitation on conflict onset

In this section we test Hypothesis 1: Lower average annual rainfall levels are associated with higher probability of conflict onset. It is common practice in the literature to use a fixed effect specification and include year dummies in the model to account for the impact of unobserved factors. We follow the same approach. We use a logistic functional form. The fixed effect model specification is as below:

$$Conflict\ Onset_{it} = G\ (\beta_1 Precipitaion_{it-1} + \beta_k X + \mu_i + \tau_t + \epsilon_{it})$$

Where G is the logistic function:

$$G(z) = \exp{(z)}/1 + \exp{(z)}$$

And X is the vector of control variables. For the purpose of identification all of our explanatory variables are measured at $t-1$. Therefore, changes in precipitation and other explanatory variables precede conflict onset in each cell. We use clustered standard errors at the cell level where the option is available.

Results and Discussion

Results are presented in Table _ and _. Model 1 in table _ provides the results of fixed effect estimation method on the impact of precipitation on conflict. All models include time dummies for each year (not included in the tables).

<u>Precipitation and conflict:</u> In model 1 we find a negative and statically significant effect from annual precipitation on conflict. Model 2 includes a set of control variables. The impact of precipitation on conflict is robust to inclusion of controls and a similar negative and significant impact is obtained. The results of model 2 indicate that each one standard deviation decrease in precipitation increases the odds of conflict onset by 45%. In table 3 we distinguish between different types of conflict. We find a negative and statistically significant impact from precipitation

[20] Using this sampling strategy will affect the estimates for intercept. Intercept estimates must be adjusted for the relative share of 1s and zeros using: $\beta_0 = \hat{\beta}_0 - ln\left[\left(\frac{1-\gamma}{\gamma}\right)\left(\frac{\bar{y}}{1-\bar{y}}\right)\right]$ where γ is the proportion of 1s in the population and $\bar{y}$ is the proportion of 1s in the estimation sample.

levels on intra-state, non-state and low-intensity conflict types. Each one standard deviation decrease in precipitation is associated with 38% rise in the odds of low intensity conflict, 30% rise in the odds of non-state conflict and 45% rise in the odds of intrastate conflict (Note that the coefficients presented in the tables are logit coefficient estimates rather than odds ration)[21].

As a robustness check we use pooled cross section and random effect estimation methods in Models 3 to 6 in Table 2. Our results are robust to these alternative estimation methods. Random effect and pooled cross section estimations do not include cell fixed effects. Therefore, the results in models 3 to 6 provide a check on robustness of results to model specifications excluding a cell fixed effect. However, as the fixed effect estimation removes the impact of unobserved time invariant cell characteristics we proceed with fixed effect estimation method.

It is plausible to think that the impact of precipitation on conflict is not constant for all precipitation levels (Although most studies report a linear relationship (Hsiang 2010). To test for the possibility of a non-linear relationship we used the lag of squared precipitation as an explanatory variable. Although the impact of squared precipitation on conflict onset is significant at 5% significance level the coefficient is very small (5.75e-06). Therefore, we report the results with precipitation levels rather than the quadratic form.

Although our primary interest is in the impact of precipitation on conflict, we need to control for other factors that might be correlated with conflict and precipitation to avoid omitted variable bias. At the same time inclusion of these control variables provides information on other sources of conflict. The vector of control variables includes: discrimination against an ethnic group, the percentage of agricultural land in a cell and population.

Discrimination against ethnic groups and conflict: The Ethnic Power Relations (EPR) dataset identifies all politically relevant ethnic groups and their access to state power (Vogt et al 2015). PRIO-GRID provides information on the number of excluded groups (discriminated or powerless) as defined in the GeoEPR/EPR data in a given year. The variable "excluded" in our models is a binary variable that takes the value of 1 if at least one ethnic group is discriminated against based on the EPR definition and takes the value of zero otherwise. We find that keeping precipitation levels and other control variables constant, political exclusion of ethnic groups has a positive and significant impact on the probability of conflict onset when we control for cell and time fixed affect.

Share of agricultural land and conflict: The variable "Lagged % Agriculture Land" gives the percentage area of the cell covered by agricultural area. Our results show that higher percentage of agricultural area in a cell has a significant and positive association with the probability of low-intensity conflict (Model 7). Each one standard deviation increase in the share of agricultural land in a cell is associated with 34% increase in the odds of conflict onset. For other conflict types the direction of the impact is similar however the impact is not significant.

[21] To obtain the change in the odds ratio for each one standard deviation change in precipitation and other explanatory variables, from the βs reported in the table, we calculate $e^{\beta\sigma}$ where σ is the standard deviation of the variable of interest.

The higher probability of conflict onset in agricultural areas might be an indication of dissatisfaction in those areas due to having a lower share from the rapid economic development in Ethiopia over the recent years. Anecdotal evidence on the recent tensions in Ethiopia show that it is partly provoked by driving off of the farmers from their lands to make way for commercial farms and factories (The Economist 2016).

To test for the possibility of this hypothesis we check whether cells with higher than median share of agricultural land have a higher income gap from the average income levels compared to other cells. We use the dollar value of cell production per capita as a measure of income for individuals within each cell. The data on the value of cell production levels is obtained from the G-Econ dataset. To obtain a measure of average per capita income we use GDP per capita data of the World Bank. Income gap is the difference between GDP per capita and cell production per capita (similar to the measure used by Buhaug et al 2011). We then run a simple t-test to see whether income gap is larger for cells for which the percentage of agricultural land is higher than median (the median of the share of agricultural land in our dataset is approximately 10%). The results of the t-test show that the income gap is significantly larger for cells with higher than median share of agricultural land compared to cells with lower than median share of agricultural land (Annex 5). This might be an indication that agricultural areas have lagged behind in the process of economic development and might have contributed to conflict incidence in those areas.

The mean difference comparison above ignores the impact of other factors that might vary between cells with higher than the median and cells with lower than the median share of agricultural land. Another possible factor that might drive this result is that there is more migration to areas with higher share of agricultural land and these movements of population is a source of conflict in those areas. However, careful analysis of the reason behind higher probability of conflict in places with higher share of agricultural land is a subject for further research and is beyond the scope of this paper.

<u>Population and conflict:</u> We control for population at the cell level and as expected, population has a positive and significant impact on conflict onset in all model specifications.

Table 2:

	Model 1	Model2	Model3	Model4	Model5	Model6
	Fixed Effect	Fixed Effect	Pooled	Pooled	Random Effect	Random Effect
ConflictOnset						
Lagged Precipitation	-0.002***	-0.005***	-0.002***	-0.005***	-0.002***	-0.006***
	-0.001	-0.001	0.0003	-0.001	0.0005	-0.001
excluded		1.751**		-0.145		-0.177
		-0.861		-0.193		-0.238
Lagged % Agriculture Land		0.014*		0.0005		0.011*
		-0.007		-0.005		-0.006
Lagged Log population		0.375***		0.469***		0.449***
		-0.075		-0.05		-0.068
constant			-2.608***	-7.268***	-4.051***	-8.528***
			-0.32	-0.596	-0.379	-0.798
LRchi2	213.1398	185.6718	166.7062	241.4126	289.3899	239.5078
N	2033	3418	3418	3403	2028	3404

Table 3: Conflict Types

	Model7	Model8	Model9
	Low Intensity	Non_State	Intra-State
excluded	14.492	14.863	0.745
	-2267.797	-777.314	-0.842
Lagged Precipitation	-0.004***	-0.003***	-0.005***
	-0.001	-0.001	-0.001
Lagged % Agricultural land	0.024**	0.015	0.013
	-0.011	-0.01	-0.008
Lagged log population			
	0.240**	0.244**	0.319***
	-0.121	-0.101	-0.078
LR chi2			
	105.7793	79.6577	302.6942
N			
	897	957	1862

Mechanism through which precipitation affects conflict

In this section we test hypothesis 2: Precipitation affects conflict through affecting total production levels. Our attempt is to disentangle the relationship observed between precipitation and conflict in section 6.1 in a "reduced form equation" and to test whether precipitation affects cell production and production in turn affects conflict onset. We use a two-stage estimation method to test this hypothesis.

We already estimated the reduced-form equation of the relationship between precipitation and conflict in the previous section (Model 2). As a reminder we repeat the reduced form specification below:

$$Conflict\ Onset_{it} = G\ (\beta_1 Precipitaion_{it-1} + \beta_k X + \mu_i + \tau_t + \epsilon_{it})$$

We begin the two stage estimation by testing whether precipitation and cell production are partially correlated i.e. whether precipitation has a significant impact on cell production levels once we control for all the control variables. The first stage results in table 4 show that partial correlation exists.

In the first stage we regress cell production on precipitation and other control variables and obtain the "predicted production" of the cells from this regression. Therefore, in stage one we estimate:

$$log\_\ Production_{it-1} = \alpha_0 + \alpha_1 Precipitaion_{it-1} + \alpha_k X + \mu_{i1} + \tau_{t1} + \epsilon_{it}$$

In stage two, we use the predicted production values obtained from stage one as an explanatory variable to regress conflict onset, while controlling for the vector of control variables *X*. The second stage equation is:

$$Conflict\ Onset_{it} = G\ (\gamma_1 log\_Pro\widehat{duct}ion_{it-1} + \gamma_k X + \mu_{i2} + \tau_{t2} + \varepsilon_{it})$$

A significant coefficient estimate for predicted production level (γ_1) in stage two would suggest that precipitation affects conflict through affecting total cell production levels.

Results and Discussion

The results of the two-stage estimation method are presented in table 4. The first stage results confirm that cell production and precipitation are partially correlated, as the coefficient on precipitation is statistically significant. The results of the second stage show a significant negative impact of "predicted" cell production levels on conflict onset. However, as we are using predicted production levels as an explanatory variable in the second stage, we do not obtain correct estimates for standard errors in the second stage. One approach to correct the standard errors is to bootstrap the two-stage estimation for repeated samples and obtain a distribution for the coefficients and their standard errors. The mean of these distributions will give us the correct standard estimates.

We bootstrapped the two-stage estimation for 100 random samples. The mean of the bootstrap coefficient and standard errors do not diverge much from the original estimates presented in table 4. For predicted production, which is the main variable of interest, the mean of the bootstrap coefficient and standard error are -8.21 and 1.589 respectively. These results correspond to a z statistic of -5.17. Therefore, the coefficient on predicted production remains significant and negative once we correct for the standard errors of the second stage. The results of the bootstrap procedure are very similar to the estimated model in table 4 for all other variables in the model. Moreover, as a robustness check, we run the two-stage estimation with linear second stage specification, using the xtivreg tool available in Stata. The xtivreg tool automatically corrects for the standard errors obtaining similar results (Annex 6).

Based on the two-stage estimation results, we can suggest that precipitation variations affect conflict onset in Ethiopia through affecting production at the cell level. To interpret these results, it should be noted that a large share of Ethiopia's production comes from the agriculture sector. Moreover, much of Ethiopia's non-agricultural production relies on raw materials from the agricultural sector (World Bank 2006). Therefore, variations in cell production in our data provide an approximation of the variations in the agricultural output in each cell. The level of agricultural products largely affects households' food security in Ethiopia (Barrios et al 2008). Therefore, it can be inferred from the model in this section that variations in precipitation affect agricultural production and food security. The agricultural production in turn affects the probability of conflict onset.

In this study we have used total cell production as an approximate indicator of food security due to the lack of data on food security indicators at the cell level. Availability of food security measures at the cell level would enable a better test of the transmission mechanism.

Key Results

Lower precipitation levels are associated with higher probability of conflict onset. The same significant association is observed between precipitation and non-state, intra-state and low-intensity conflict types: High sensitivity of the Ethiopian economy to rainfall variations has been long identified as a major challenge by Ethiopian policy makers and international organizations. Our results indicate that sensitivity to rainfall can also destabilize the country through increased probability of conflict.

Ethiopia has made significant efforts to increase household resistance to shocks and droughts. As a result, it has achieved strong economic growth particularly since 2004 when growth rate has continuously stayed at above 8 percent. Ethiopia's overall economic policy called the Agricultural Development Led Industrialization (ADLI) aims to address Ethiopia's food security and agricultural productivity challenge. Commercializing of the agriculture sector and income diversification through non-agricultural activities are among the goals of the ADLI. The need for commercialization of agriculture and increased share of industry have been picked up as a priority in several shorter term government plans such as the Plan for Accelerated and Sustained Development to End Poverty and the Growth Transformation Plan (United Nations, "Development Strategies that Work" database 2007).

Moreover, The Ethiopian government in cooperation with international organizations such as the Food and Agricultural Organization of the United Nations, the World Bank and the World Food Program has implemented several policy responses to enhance the economy's resistance to weather variations and enable the poor to resist shocks. The Productive Safety Net Program established in 2005 in cooperation with the World Food Program is implemented in nine regions of Ethiopia and aims at enabling the rural poor facing food insecurity and shocks. The program has been assessed to have improved food security and agricultural productivity of the targeted households (WFP Productive Safety Net Program Factsheet 2012).

Table 1: Two-Stage Estimation

	First Stage	Second Stage
	Total cell production	Conflict Onset
excluded	-0.052	1.384
	-0.104	-0.859
Lagged Agricultural land	-0.002	0.001
	-0.001	-0.007
Lag_log population	0.979***	7.307***
	-0.012	-0.947
Lagged precipitation	0.001***	
	0.0001	
	-	
Predicted Production		7.082***
		-0.938
constant	-14.173***	
	-0.141	
LR chi2		289.3899
N	3403	2028

Despite all these efforts, Ethiopia remains one of the poorest countries in the world and the income per capita of USD 590 is substantially below the regional average (World Bank 2016). The pace of transformation towards a more resilient economy has lagged behind the government targets.

The Growth Transformation Plan targeted to reduce the share of agriculture from the GDP to 41.6% by 2010 and to 38.7% by 2013. However, the actual figures show that the share of agriculture sector only marginally reduced to 44.4% by 2013. At the same time the share of industry targeted to increase to 15.3% only reached 10.8% by 2013 (IMF 2014).

At the same time, there has been an acceleration is dryness in Ethiopia over the past decades. There has been a 15-20 percent decline in spring and summer rains in parts of Ethiopia since the mid-1970s. The Famine Early Warning Systems Network estimates a total loss of more than150 mm of rainfall per year in the most densely populated long cycle crop growing area of Ethiopia, by extending the rate of observed 1960–2009 changes in rainfall for each season, through 2010–2039, based on an assumed persistence of the observed trends.

Therefore, it seems that due to a combination of rapid loss of rainfall and lagging behind the targets in decreasing Ethiopia's reliance on rain fed agriculture, the country is still sensitive to precipitation variations. As a result, we still observe a significant impact from precipitation variations on probability of conflict in Ethiopia.

Higher share of agricultural land in a cell has a positive and significant impact on the probability of low intensity conflict: This result might be driven by lower share of agricultural areas from the rapid economic growth in Ethiopia over the recent years as the income gap from the average was significantly larger in cells with higher than median share of agricultural land than cells with lower than median share of agricultural land. However, there might be other variables affecting populations in cells with high and low share of agricultural land. Another possible interpretation of this result is that there might be more migration to areas with higher share of agricultural land and this might be a source of conflict.

Cells in which discrimination against at least one ethnic group is recorded are more likely to experience conflict: Ethiopia has adopted a federalist political system since 1991 based on ethnic regional administrations. However, limited space for opposition has resulted in an effectively one party system in Ethiopia with EPRDF and its affiliate parties controlling 99% of the seats in the parliament in 2010 elections. Moreover, re-centralization of the decisions on agricultural investment in 2009 has created opposition particularly in the Oromiya region (Lavers 2012). Therefore, ethnicity remains a source of conflict in Ethiopia over the period of this study.

Precipitation affects conflict through affecting total production levels: Based on the results of our two-stage estimation method, precipitation affects conflict through affecting total production levels. Therefore, lower precipitation results in lower production and lower production in turn results is higher probability of conflict. As most of Ethiopia's production either comes directly from the agricultural sector or relies on agriculture for its raw material (World Bank 2006), here we can look at the total production figures as an approximation for the level of agricultural production.

6. Food, Drought and Conflict: Evidence from a Case-Study on Somalia

This paper aims at disentangling the mutual link between conflict, drought and food security in Somalia. The analysis is conducted using various indicators for food security and on different (national and sub-national) aggregation levels. The evidence is partly based on data from a household-level survey, collected in various regions in Somalia in 2013. In addition, we use geo-spatial district level data, which combines (geo-referenced) drought data, with information on conflict from the joined ACLED-PRIO database, together with other location-specific variables.

Overall, we find a positive effect of drought on the percentage stunted individuals on the district level. Interestingly, we find evidence for a U-shaped relationship between drought and underweight individuals. In addition, we find a similar U-shaped relationship between drought and the normalized maize-sorghum price index. On the household level, based on evidence from a Somaliland and Puntland survey, we find a positive effect of rainfall-based drought on food security outcomes. However, using a data from an impact evaluation in Doolow (Gedo region), we find a negative effect of drought on non-food expenditures, affirming the hypothesis that households in distress will buy less non-food items when confronted with distressing situations. Furthermore, we find an increasing effect of intrastate conflict on the percentage underweight individuals on the district level. On the household level, we find a strong evidence for a negative effect of conflict on non-food expenditures, which also confirms the household coping strategy hypothesis. On the district level, we do not find evidence that drought triggers conflict. In contrast, on the household level we find strong evidence for this, suggesting that conflict analysis at a lower aggregation level does reveal some findings that we may not pick up on when running the analysis at a higher aggregation level.

Study context

One important control variable is the severity of drought experienced in a given month. Extreme weather events have become more frequent over the past decades. More specifically, Somalia has witnessed a steady increase in drought intensity over the past decades. Due to its geographic location and fragile environments, Somalia is highly vulnerable to weather shocks - particularly droughts (FSNAU, 2011). In 2011, Somalia experienced one of the most severe droughts since 50 years (Maxwell and Fitzpatrick, 2012). Drought has been found to trigger conflict by various authors (Maystadt and Ecker, 2014; Raleigh et al., 2015). Given the protracted and complex crises experienced by Somalia in the last years, studying the link between conflict, drought, and food security is of primary interest.

A vast amount of literature has identified food security to be an important threat to violent conflict. At the same time, conflict also poses a threat to food security, both directly and indirectly. For example, conflicts may destroy transportation infrastructure or diminish productive assets which could lead to income losses. A key issue in this analysis is therefore to try to tackle or avoid the issue of reversed causality.

Furthermore, data limitations is another key problem. E.g. anthropometric indicators of food security – such as the prevalence of stunted and underweight individuals, etc. – are not available on a yearly basis over a long time period. Therefore, the choice of the food security indicators in this chapter has been based on the availability of data with a reasonable time and spatial coverage. Nevertheless, most of the food security variables used span a relatively short time period.

Over the past decades, the state of certain food security indicators has vastly improved, whilst less progress has been booked on others. Figure 1 shows the evolution of a few food security indicators for Somalia over time, spanning the time period between 1990-2013. Prevalence of anemia among 5 year old children seems to be overall declining, while access to water has improved significantly as well. Per capita food production variability and mostly cereal import dependency ratio don't follow such a clear downward trend and seem to be responding more to external shocks like political instability, conflict, etc.

Figure 1: Evolution of food security indicators over time, 1990-2013. Data are collected from the FAO set of food security indicators database (2016).

Intrastate and Internationalized Intrastate categories of conflict correspond to the definitions used in the UCDP/PRIO Armed Conflict Dataset. One-sided conflict events are events where civilians are targeted. Figure 2 depicts the trends for these conflict categories. There seems to be an upward trend for one-sided, intrastate, as well as internationalized intrastate events. One-sided events and intrastate conflict events are most prevalent, even though internationalized intrastate conflict has risen sharply.

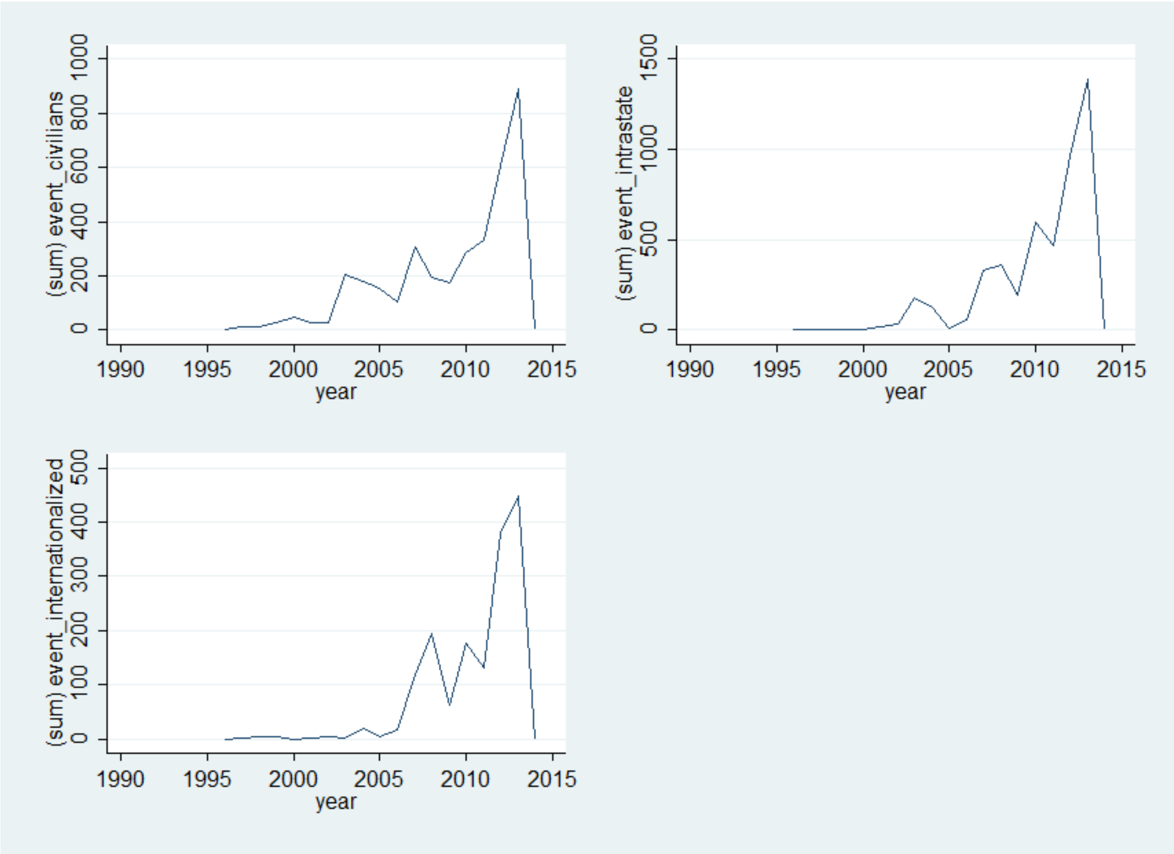


Figure 2: One-sided and intrastate conflict, by district and year (1997-2013), ACLED-PRIO, 2016.

Figure 3 depicts the intrastate and one-sided conflict events by district. Clearly, there is a large variation among districts. Most of the violent conflicts are taking place in the Banadir district/region due to the presence of the capital. Figure 4 depicts local district prices of for 1kg of white maize and 1 kg of red sorghum. Local district prices seem to vary in terms of volatility. The observed variation in conflict intensity and food prices (and other food security indicators) among districts and regions makes it worthwhile to study the relationship between conflict and food security on different levels of aggregation.

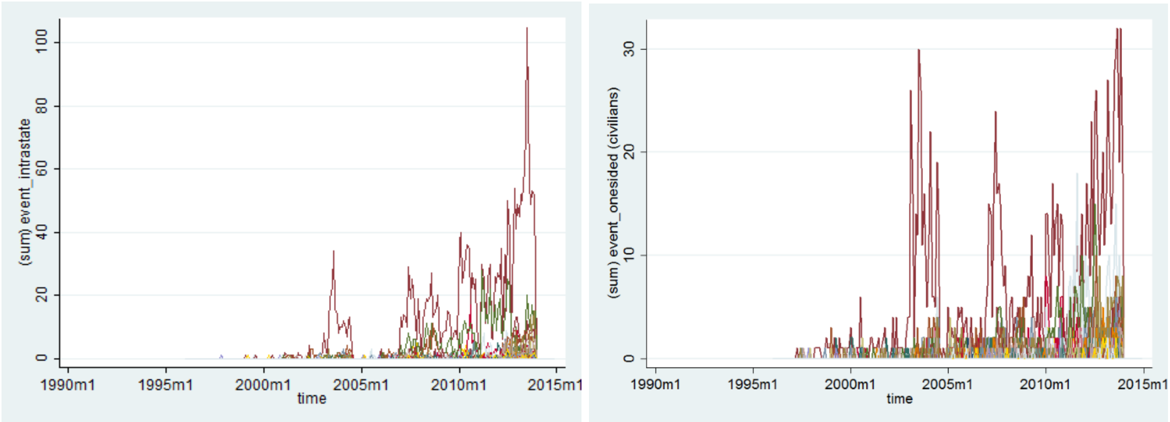


Figure 3: Onesided and intrastate conflict, by district and year (1997-2013), ACLED-PRIO, 2016.

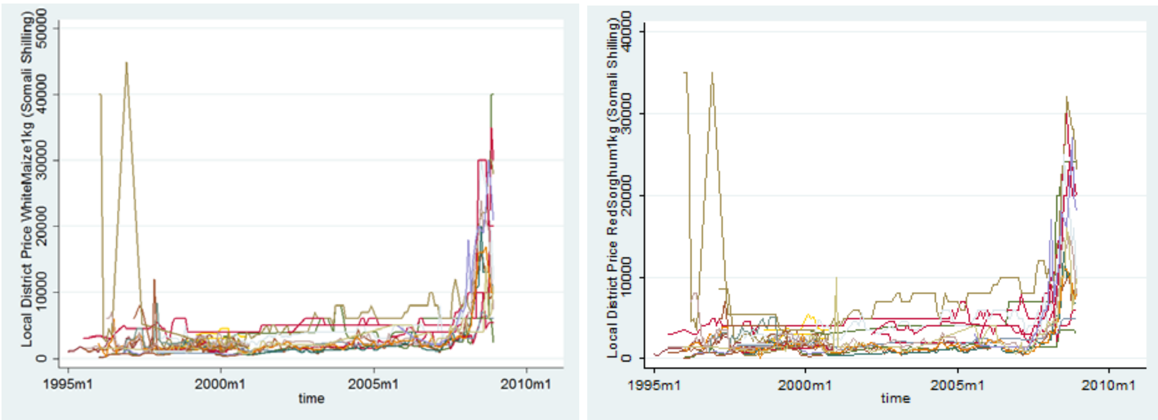


Figure 4: Local district prices for 1kg of white maize and 1 kg of red sorghum, 1996-2008. FNSAU, 2016.

Figure 5 depict the distribution of violent events (left map of Somalia) and fatalities, within the regions of Somalia. Violent events and fatalities seem to be more concentrated in the South and South-West of the country, and alongside the border with Ethiopia. We will study the impact of conflict and drought on food security outcomes, both on the district level as well as the household level. Our data on the district level is spread over the districts (and regions) of the entire country, whilst the household level data are restricted to the districts of Bosasso and Iskushuban in the northeastern Bari Region (Puntland) and Burao and Odweyne districts in the northwestern region of Toghdeer (Somaliland).

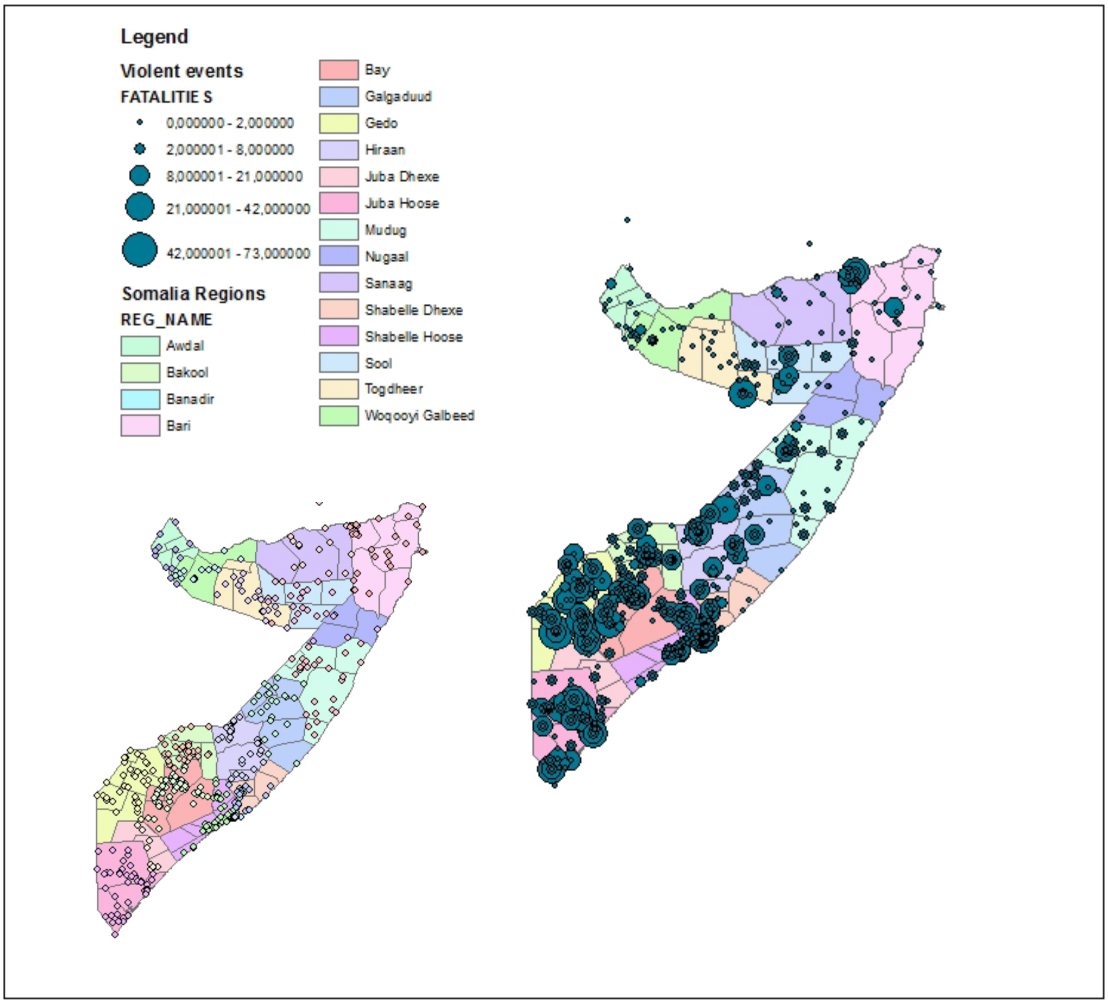


Figure 5: Distribution of violent events (left) and fatalities (right) in the regions of Somalia. Author's calculation based on ACLED-PRIOGRID data (1997-2014).

Methodology and data

District level: Empirical strategy

In this section, we will examine the impact of conflict and drought on food security at the district level. Both drought and conflict are expected to have a negative effect on food security outcomes. In addition, drought is likely to affect conflict, according to the literature (Maystadt and Ecker, 2014; Raleigh et al., 2015). Therefore, examining the link between them is highly recommended. For our analysis, we will use various food security variables, both anthropometric measures and price indicators, spanning different time periods. Likewise, and in line with the overall strategy set out in this report, we will look at various conflict categories: violence against civilians (onesided), intrastate violence, internationalized violence, as well as 'low-intensity' conflict where a low threshold of 5 battle deaths per month is used, and up to a maximum of 100 battle deaths per month.

Furthermore, the link between food-security and conflict is likely to suffer from reverse causality as the main source of endogeneity. To account for endogeneity due to simultaneity bias, we instrument the conflict variables with the corresponding conflict variable lagged over one time period and the history of conflict events, given its significant impact on ongoing conflict[22].

Besides conflict, according to the literature, there are several variables that can affect the food security situation of our unit of analysis (districts – households). In this study, several additional district-specific control variables are used, obtained from combining geospatial datasets. More detailed information on control variables and data is described in the next section. We start by examine the effect of drought on both conflict and food security outcomes in separate bivariate regressions. Then we will run the full model including all relevant control variables.

$$FoodSecurity_{it} = \alpha + \beta_1 Drought_{it} + \beta_2 X_{it} + \mu_i + \eta_t + \epsilon_{it}$$

$$Conflict_{it} = \alpha + \beta_1 Drought_{it} + \beta_2 X_{it} + \mu_i + \eta_t + \epsilon_{it}$$

We expect to find a positive triggering effect of drought on conflict. To avoid introducing endogeneity into our model, we will exclude the drought variable from the following equation, which measures the impact of conflict on food security:

$$FoodSecurity_{it} = \alpha + \beta_1 Conflict_{it} + \beta_2 X_{it} + \mu_i + \eta_t + \epsilon_{it}$$

The subscripts i=1,...,C and t=1,...,T denote district and time (monthly level), respectively, $FoodSecurity_{i}$ the food security indicator; $Conflict_{it}$ is the conflict variable, $Drought_{it}$ the drought variable, X_{it} is a vector of controls, μ_{i} and η_{t} are district (or region) and year fixed effects, respectively, and ε_{it} is the error term.

By controlling for district-fixed and time-fixed effects in all regressions we address the potential problem of omitted/unobserved variables in a general manner. The district-fixed effects variables pick up time-constant, unobserved heterogeneity across districts, for instance ethnic composition of the population. The time-fixed effects variables control for external shocks that affect all of Somalia similarly. In a few bivariate regressions, we leave out the time and district dummies and

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22 A relatively new test for exogeneity of a single explanatory variable in a multivariate model, which doesn't require instrumental variables for testing, has been developed by Caetano (2015). Another study by Caetano et al. (2015) shows that this exogeneity test is able to detect endogeneity resulting from omitted variables, simultaneity, measurement error, and misspecification errors. The test consists of estimating the expected outcome variable conditional on all the observed variables, and assessing whether it is discontinuous in the variable whose exogeneity requires testing. If a discontinuity is found, then the variable is endogenous. The main assumption of this test is that the model must be continuous in the explanatory variable of interest, which is the case for the conflict variables used in this study. Furthermore, the source of endogeneity (unobservables, simultaneity, etc.) should be discontinuous around the zero threshold (of the explanatory variable), and the test is particularly suitable for bunching (clustering) models The latter assumption we cannot make for the relationship between food-security and conflict.

add them in a later stage. All regressions are run using clustered standard errors at the district level (or regional level for the regressions including anthropometric food security variables).

As a robustness check, we adjust error terms for spatial and time dependency since there may be not enough district units in our dataset for clustering standard errors. To adjust standard errors for spatial and temporal correlation, we adopt Hsiang's (2010) procedure. We allow for a time dependency of up to three months, and a distance cutoff point of 160 kilometers, which is the average distance between the centers of neighboring districts. Using standard errors adjusted for spatial and temporal correlation is appropriate in cases in which spatial correlation is present in the error term (spatial error model), and has been performed in a vast amount of literature when using geo-referenced data. However it does not address the issue of how to explicitly model spatial dependence in the process itself (conflict and drought spillovers).

Data

Estimations are based on monthly panel data at the district level. Somalia has 18 administrative regions and 74 districts, and the time frame of our analysis ranges from January 1997 to December 2013 (with exception of some regressions). Since we use various food security indicators throughout the analysis, the number of observations differs depending on which indicator is used.

As anthropometric measures of food security, we use district (and region, livelihood) specific data on the percentage of the population that is underweight and/or stunted, from the Food Security and Nutrition Analysis Unit, Somalia (FSNAU) Integrated Database System. This data is available for both rainy seasons *Deyr* and *Gu*, covering a limited time-span of 5 years between 2009-2014. The data is derived from the Nutrition Datasets. Since stunting is a long-term measure of food security, and is highly likely to be correlated with stunting in previous time periods. To account for the dynamics of the model, we will take into account past observations of the stunting variable. In particular, we will include the 3-month lag of the stunting variable in the regressions equation. An individual (children aged between 0-59 months for the FSNAU data) is stunted whenever the "height for age" value is two standard deviations below the WHO Child Growth Standards median. In the regressions where the stunting variable is the dependent variable, 3-month lags of the conflict and drought variables will be used, to take into account the time needed for stunting to become apparent.

Furthermore, we use local district monthly price data from the FNSAU Integrated Market Database System as a basis to build additional food security indicators. More specifically, we construct a normalized price index of maize and sorghum – two major food crops in Somalia – using local district prices for 1k white maize, yellow maize, white sorghum and yellow sorghum. To control for price inflation, prices are normalized by dividing them by the price of imported red rice, which doesn't lead to biased estimates according to Maystadt and Ecker (2014), who apply a similar normalization procedure. A final indicator is the price volatility of the combined maize-sorghum price. The price volatility is calculated using the Gilbert and Morgan (2010) volatility measure.

The conflict variables (onesided, intrastate, and internationalized) are constructed as the sum of respectively onesided (against civilians), intrastate, and internationalized violent conflict events in each administrative unit per month, using the combined PRIO-ACLED dataset (2016). The dataset reports 12,287 conflict events in Somalia between 1997 and 2013, of which the majority were violent (including battles between conflict groups and violence against civilians). In addition, a dummy variable *lowintensity* is constructed, taking on value 1 whenever the threshold of 5 battle deaths per time period is reached, with a maximum of 100 battle deaths. Because we look at monthly data instead of yearly data, the threshold of the *lowintensity* variable is set lower than the threshold used by PRIO/UCPD where a minimum of 25 battle deaths per time period is needed.

This dataset is spatially merged using the geostatistical software ARCGIS to the PRIOGRID database, which contains a range of grid-cell specific data on socio-economic conditions, ethnic groups, climatic conditions, etc. For the regressions at the district level, this spatial data is averaged over the grid cells of the country's district. Spatial information on the district (and regional) border within the country is derived from the GADM database of Global Administrative Areas, version 2.8, 2015.

The variable *drought* captures the severity of drought measured at the grid cell's level, in a given month. The severity value is the SPEI1 value, obtained from the Standardized Precipitation and Evapotranspiration Index SPEI1 from the SPEI Global Drought Monitor. The values are standardized where deviation estimates less than 1 standard deviation indicate near normal rainfall. The monthly SPEI1 index measures deviation from long-term normal rainfall for that month (Bergueria et al., 2014). In this study, the deviation values (anomalies) should be interpreted as follows: months that are drier than normal have a positive precipitation anomaly and months that are wetter than normal have a negative precipitation anomaly. In some of the bivariate regressions, we also look at temperature (*temp*) instead of drought. This variable gives the yearly mean temperature (in degrees Celsius) in the grid cell, based on monthly meteorological statistics from GHCN/CAMS, developed at the Climate Prediction Center, NOAA/National Weather Service (Fan and van den Dool, 2008).

In addition to drought, other variables from the PRIOGRID database are added to the regression equation. *capdist* captures the distance to the nearest national capital from the centroid of the grid cell, indicating the remoteness of the district. Even though this data is time varying, the variation over time is small and therefore this variable will only be included when no district (or regional) dummies are added to the regression. This is however an important control variable, since nowadays the majority of poor and food insecure people still live in remote areas. *lnpop* measures the grid-specific population, taken from the 'Gridded Population of the World', version 3. Population estimates are available for 1990, 1995, 2000, and 2005. The remaining data points are calculated based on interpolation. Finally, we control for history of conflict by taking into account the total number of violent events, lagged by 2 years. Below, Table A summarizes the descriptive statistics of the regression variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
pcunderweight	377	23,421	12,748	2,600	61,800
pcstunting	375	21,079	12,513	0,400	48,700
nprice_maizesorghum	5438	0,467	0,242	0,023	3,333
volatility	4080	0,182	0,198	0,002	3,202
event_onesided	16872	0,211	1,254	0,000	32,000
event_intrastate	16872	0,280	2,376	0,000	105,000
event_internationalized	16872	0,092	0,677	0,000	16,000
event_lowintensity	22242	0,024	0,152	0,000	1,000
drought	8600	0,250	1,011	-5,206	5,832
temp	21036	29,571	3,110	21,486	38,137
lnpop	21012	11,565	1,767	0,000	21,084
capdist	21036	532,197	322,569	24,070	1252,423
events_history	22052	29,958	181,662	0,000	4167,000

Table A. Descriptive statistics – district level

Household level

At the household level – in line with the analysis at the district level – we look at the impact of conflict exposure and drought on the various food security measures. Firstly, we examine the effect on the food consumption score (*fcs*) of the household. The food consumption score captures the dietary diversity and nutrient value of food consumed by households. It is calculated from the types of foods and the frequency with which they are consumed over a seven day period (FAO 2016), reported by the respondent. The threshold for being considered as food secure it set at 28. Below this threshold, a household is considered as food insecure. Furthermore, we examine the effect of conflict exposure and drought on food expenditures (*food_exp*) of the household and non-food expenditures (*nonfood_exp*). The amount a household spends on food is an indicator for household food security. However, in times of distress, the household will more likely cut down on the expenses on non-food items first, since food consumption is a more basic need than non-food consumption. Therefore, it is interesting to look at how both variables behave under conflict and drought exposure.

To measure the household's conflict exposure, we use information on the threat of conflict (none, low, medium, high) between clans in daily life. This *conflict* variable is reported by the household and can be interpreted as a perception of conflict threat (or lack thereof). Ideally, we would like to have information on conflict shocks, to avoid simultaneity bias.

All the household data are derived from a household level survey, conducted in June 2014, in various districts and regions in both Somaliland and Puntland. This survey is part of the Impact Evaluation of the Joint Resilience Strategy of FAO, UNICEF and WFP in Somalia. The survey sample in Puntland consisted of 809 households: 297 in Bossaso and 512 in the Iskushuban district. The total number of individuals covered by the survey was 5,228 of which 1,993 were in Bossaso, and 3,235 in Iskushuban, comprising 49.9% females and 51.1% males. The sample in Somaliland included 802 households: 368 in Burao and 434 in Odweyne district, 74.2% of the total were maleheaded households and 25.8% were female-headed households. The total number of individuals covered by the survey was 4 696; 2160 in Burao, and 2 536 in Odweyne. The largest group of household livelihoods in Puntland is urban (29%), followed by Internally Displaced Persons (IDPs) with 28%. The pastoralists make up 15% of households, the fishing community are 13.6%; farmers 7% and agro pastoralists are 6.5% of households. In contrast, in Somaliland the households interviewed were mainly pastoral (75%), followed by agro-pastoralist (almost 21% of the households). Urban (together with IDPs and farming livelihoods) represent less than 5% of the livelihoods in Somaliland (FAO, 2016a; 2016b). Below, Table B summarizes the descriptive statistics of the regression variables. Interestingly, urban households have a higher food consumption score (about 18%) compared to pastoral households. At the same time, urban households seem to have reported lower threats of conflict (12% lower) between clans than pastoral households. Thus, living in urban areas seems to be associated with higher food consumption scores, but at the same time lower reported threats of conflict, when compared to pastoral households. This result may be driven by differences in household income, market access, food prices, etc. Controlling for these factors will be essential in determining the causal relationship between conflict and food consumption scores at the household level.

Variable	Obs	Mean	Std. Dev.	Min	Max
fcs	1568	55,756	18,838	0,000	112,000
fcs_urban	315	61,561	20,024	0,000	107,333
fcs_pastoral	690,000	52,253	15,552	0,000	112,000
log food_exp	1595,000	13,220	3,279	0,000	17,016
log nonfood_exp	1595,000	12,919	1,760	0,000	15,396
conflict	1573,000	0,240	0,730	0,000	3,000
conflict_urban	313,000	0,291	0,837	0,000	3,000
conflict_pastoral	701,000	0,331	0,841	0,000	3,000
drought	1591	0,873	1,241	-0,542	2,270
log formal_transfer	1595,000	3,113	5,531	0,000	16,148
log informal_transfer	1595,000	2,048	4,856	0,000	17,687
femhead	1595,000	0,246	0,431	0,000	1,000
hhsize	1595,000	6,238	2,726	1,000	17,000
educhead	1421,000	2,080	3,368	0,000	13,000
log totincome	1503	11,445	4,726	-0,021	17,759
urban	1595	0,197	0,398	0,000	1,000
distance_market	1581	-18,774	23,726	-130,000	0,000
shagr_wge	1466	0,003	0,050	-0,063	0,979
shnonagr_wge	1466	0,226	0,392	-0,776	1,500
shcrop	1466	0,026	0,160	-0,787	2,737
shlivestock	1466	0,453	0,477	-1,532	2,723
shselfemp	1466	0,154	0,384	-2,227	2,698
shtransfer	1466	0,097	0,258	-1,526	1,625
shother	1466	0,041	0,164	-0,136	1,535

Table B. Descriptive statistics – household level

The survey data are combined with monthly varying spatial drought data from the SPEI Global Drought Monitor. This information is merged to the household-level data, based on information on the district location of the household. Unfortunately, there is no information on the exact location of the household given that the spatial coordinates of the household are not available.

In more general terms - similar to the district level but with a different set of control variables - we run the following regressions:

$$FoodSecurity_i = \alpha + \beta_1 Drought_i + \beta_2 X_i + +\mu_i + \epsilon_i,$$

to measure the effect of drought on food security. We also examine the effect of drought on conflict and the effect of conflict on food security:

$$Conflict_i = \alpha + \beta_1 Drought_i + \beta_2 X_i + +\mu_i + \epsilon_i$$

$$FoodSecurity_i = \alpha + \beta_1 Conflict_i + \beta_2 X_i + +\mu_i + \epsilon_i$$

where the subscripts i=1,...,C denote district; *FoodSecurity*_{i} the food security indicator; *Conflict*_{i}is the conflict variable, *Drought*_{i} the drought variable; *Conflict*Drought*_{i} the interaction term, X_{i} is a vector of controls, and ε_{i} is the error term. Regressions are run using ols regression and standard errors are clustered at the district level. District dummies (or regional dummies) are excluded from the regression since there are not enough districts covered to cluster standard errors.

In line with the previous section, we add the following set of control variables measured at the district level: drought (interacted with the conflict variable), the log of the district population, distance to the capital and history of conflict events. We also control for a number of control variables measured at the household level, since they may affect a household's food security situation as well: household size (*hhsize*), the log of monthly household income (*loghhincome*), the distance to the nearest market – an indicator of market access, and a set of variables depicting the percentage of total household income derived from agricultural wage or non-agricultural wage employment, crop or livestock production, transfers, and self-employed activities (*shagrwage, shnonagrwage, shcrop, shlivestock, shselfemp, shtransfer*). We also include information on the distance to the nearest market and health facility. This information could also a serve as a measure of proximity to urban areas. Furthermore, a dummy variable indicating whether the household is headed by a female (*femhead*) is added to the regression. The latter is an important determinant of household wealth, given the fact that female headed households are comparatively income-poor (Buvinic and Gupta, 1997; Fafchamps and Quisumbing, 2002). Finally, education of the household head is taken into account (*educhead*). Education is an important tool to reduce poverty and to fight food insecurity, as it creates better future income opportunities by targeting illiteracy and the lack of numeracy.

Finally, to corroborate our findings, we will supplement the analysis with data from an impact evaluation, carried out in April 2013 (baseline) and April 2015 (midline). This impact evaluation was commissioned by …. To improve the conditions of households in Somalia, and to build resilience, a JRS programme was adopted jointly by FAO, WFP, and UNICEF. One of the programme's main purposes was to improve household income generating capacity through a set of interventions. Households in the Doolow district received the treatment in 2013, while households in the Luuq district did not (control group). To verify the effect of the treatment on food security outcomes, we will use a difference-in-difference estimation. Due to a lack of reliable conflict data that contains enough variation, we will not be able to include a conflict variable in the analysis. In one of the regressions, drought (lag) is included as a control variable.

Discussion of results

We perform our analysis on different aggregation levels, namely the district level and the household level. The advantage of lower aggregation levels is that certain effects that may cancel out on a higher aggregation level (even on the district level), can be picked up on in lower aggregation level analysis. In addition, the household level analysis offers more details on household characteristics, which we can account for. We exploit the available information on the type of livelihood to complement our analysis to see whether the type of livelihood matters for the obtained results.

We start our analysis by running a set of bivariate regressions of the drought variable on the percentage underweight individuals and stunted individuals (Table 1, Table 2). As a comparison, we do the same for the temperature variable. This analysis is performed at the livelihood level, including agro-pastoral, pastoral, riverine, and urban livelihoods. We expect to find positive effects of conflict on anthropometric measures of food security. (The effect on prices and volatility is less clear.) Table 1 displays the result of all livelihoods together and Table 2 does this separately. Overall, drought seems to have an increasing effect on the percentage stunted individuals. As a robustness check, we also include the quadratic term of the drought variable. This doesn't seem to alter the analysis. However, Table 2 shows that for urban households, the relationship between drought and percentage underweight individuals is likely to be quadratic (U-shaped). This suggests a U-shaped relationship between drought and underweight individuals. Both for very low levels of drought (or a lot of rainfall), and for very high levels of drought, there will be an increase in the percentage of underweight individuals. Maertens (2016) finds a similar U-shaped relationship between rainfall (very low and high levels of rainfall) and conflict risk. Temperature seems to have a strong positive effect on both stunting and percentage underweight individuals.

Table 3 shows the effect of the conflict variables (one-sided, intrastate, internationalized, and low intensity conflict) on the percentage underweight and stunted individuals. Only intrastate conflict seems to have an increasing effect on percentage underweight individuals. Adjusting standard errors for spatial and temporal correlation doesn't seem to alter these findings (Table 4).

Examining the regression results at the district (not livelihood) level (Table 5, 6), we do not find evidence for an effect of drought on most of the conflict variables. Temperature seems to affect low intensity and internationalized conflict positively. Adding time and district dummies to the regression in Table 6, cancels out the effect of temperature on conflict. However, drought is more than just heat or absence of rainfall (what our drought variable measures), it is the combination of high temperatures and low rainfall. When including both drought and temperature in the regression, the drought variable becomes significant.

Looking into the effect of drought on the normalized maize-sorghum price index (Table 7), we find a very small negative price effect, but this disappears when introducing the time and district fixed effects. In addition, again the squared term becomes significant and negative, suggesting the presence of a U-shaped relationship between drought (representing absence of rainfall when positive, and presence of rainfall when negative) and the normalized maize-sorghum price index. Temperature has a small negative effect on prices, and a small positive one on volatility. However, these effects disappears when controlling for time and district fixed effects, while the effect of drought on the normalized prices remains. This may be due to the fact that the temperature variable measures yearly mean temperature, rather than temperature anomalies, and may therefore not display enough variation.

Table 8 displays the results of the regressions of the conflict variables on the price variables. Whilst there is no evidence of an effect here, using adjusted error terms for spatial and temporal correlation (Table 9) slightly alters the estimation results of the model. One-sided conflict and internationalized conflict both affect the price variables (price and volatility respectively) positively. On the household level, we use different food security outcomes, namely the imputed food consumption score, based on food consumption measured over 7 days prior to the interview, food expenditures, and non-food expenditures. These variables are directly related to food prices, since prices will determine the household purchasing power[23]. As mentioned before, studying expenditures on non-food items may be interesting, because cutting expenses on non-food items may serve as a household coping strategy in times of hardships.

Table 10 and 11 respectively shows the results of bivariate regressions of drought (temperature) on food security outcomes and conflict. Table 10 shows that drought seems to have a positive effect on all food security outcomes, whilst temperature has a negative one. When including both rainfall-based drought and temperature in the regression equation, the signs remain the same, but the temperature effect seems bigger than the rainfall-based drought effect. From Table 11, we learn that drought has a positive triggering effect on conflict exposure, as experienced by the household. At the household level, we do not include the quadratic drought term, because of collinearity with the drought variable. Table 12 shows the result of the regressions of the conflict exposure measures on the food security outcomes. We find a positive effect on the food consumption score. However, this variable may not adequately measure food insecurity. When looking at food and non-food expenditures, we see a negative effect of conflict exposure on consumption of non-food items. This is in line with the 'coping strategy hypothesis'.

Finally, Table 13 displays the results of the difference-in-difference estimation of the treatment effect of the 'building resilience' program on the food security outcomes. We find a positive treatment effect of the program on household food expenditures. When including drought as a control variable, this positive treatment effect on food expenditures disappears, but the effect on non-food expenditures becomes apparent. Interestingly, the drought variables has a strong negative effect on non-food expenditures, which is again in accordance with the coping strategy hypothesis. This finding is according to expectations, and in contrast with the positive drought effect found in Table 10. The latter could be explained by the fact that the difference-in-difference estimation used panel data (a two year panel), as opposed to the cross-sectional analysis of the Somaliland and Puntland survey data.

Conclusion

Overall, we find a positive effect of drought on the percentage stunted individuals on the district level. Interestingly, we find evidence for a U-shaped relationship between drought and underweight individuals. In addition, we find a similar U-shaped relationship between drought and the normalized maize-sorghum price index. On the household level, based on evidence from a

[23] The household dataset allows us to distinguish between urban and pastoral households (the biggest groups in the dataset). Since urban households tend to be net food buyers, they will likely profit from lower food prices, while pastoralists may suffer more from it or profit from it, depending on their net food production status (pastoralists are traditionally livestock herders). As such, we may find a differential effect of conflict on the food security score for both livelihoods.

Somaliland and Puntland survey, we find a positive effect of rainfall-based drought on food security outcomes. However, using a data from an impact evaluation in Doolow (Gedo region), we find a negative effect of drought on non-food expenditures, affirming the hypothesis that households in distress will buy less non-food items when confronted with distressing situations.

Furthermore, we find an increasing effect of intrastate conflict on the percentage underweight individuals on the district level. On the household level, we find a strong evidence for a negative effect of conflict on non-food expenditures, which also confirms the household coping strategy hypothesis. On the district level, we do not find evidence that drought triggers conflict. In contrast, on the household level we find strong evidence for this, suggesting that conflict analysis at a lower aggregation level does reveal some findings that we may not pick up on when running the analysis at a higher aggregation level.

Another reason the findings in Ethiopia are important is because it underscores complexity of how governance and administrative capacity cuts across the interaction between food security and conflict. The conflicts in Ethiopia in recent times have been comparably low intensity, and while the government and economy have been strong it remains important to recognize that conflict continues to have a detrimental effect on food security. This presents a challenge though, since the FAO and other food security actors will have to work with a strong government and navigate the political issues that underlie the reasons for food distribution and food access issues in a country like Ethiopia.

7. The Findings and their Value for Policy-making and Research

Introduction

The previous chapters demonstrate that while there is a relationship between conflict and food security at a statistical level, conflict categories and governance capacity are key to understanding the types of food insecurity people will face during conflict. The case studies also demonstrate the possibilities for increasingly accurate measurement of the relationship between food security and conflict using sub-national geo referenced data. For example, in Somalia we can see patterns in how food security is distributed geographically during upticks in violence; the closer people are to urban areas, the higher their food security. This is useful information for policy makers who are tasked with food aid delivery tasks and understanding the coping behaviors of conflict-affected populations, and speaks to issues in conflict theory about urban versus rural dynamics in conflict-affected states.

This chapter will address potential policy interventions drawing on the clusters developed in the analytic framework. This exercise is inherently qualitative and generalized, since each potential conflict situation within a cluster is going to be contextually unique. The main issue we want to address is that as conflict intensity increases, and government capacity decreases, the food security issues will change in intensity and nature and demand different policy approaches from FAO and other UN agencies, international organizations, donor governments, and national governments. Since any partnership comes with increased institutional complexity we aim to clarify where FAO can intervene on its own, and when it becomes advantageous to take on the more challenging task of coordinating with partner agencies.

The report will close with an analysis of ongoing data challenges that would need to be addressed to more fully understand the specific relationships between conflict and food security at different levels of analysis. We also tie this analysis into further policy development questions, explaining how improvements in multidisciplinary cooperation between food security and conflict specialists can lead to understanding food security as peacebuilding, and vice versa.

Potential Policy Interventions

The recognition of food security and peacebuilding being an integrated process creates opportunities for identifying interventions that can be implemented in different food security-conflict contexts. We refer to the clusters in the analytic framework and make recommendations that can be implemented directly by FAO, and in cooperation with other UN and international organizations.

In Type 1 conflict states:

In a situation where there is a functioning administration and the food security problems are more likely to be related to distribution issues as opposed to outright shortages, focusing on domestic administrative and policy issues is an appropriate route. Depending on the intensity and breadth of the conflict options could include advising on price and distribution regulations to account for imbalances in how food is distributed which could include coordinating with entities like the World Bank, but in higher intensity conflicts distribution to conflict-affected regions may only be possible with the help of peacekeepers or security forces.

In Type 2 conflict states:

In these countries the government may still exist in principle, but likely no longer has the capacity to import, produce or distribute food. Unlike the Functional Conflict scenario, these countries are likely dealing with acute food shortages and not enough available calories for the population. This could mean coordinating food aid, as well as working with peacekeepers or security services to deliver food to conflict-affected areas. This context is challenging since food aid itself has been observed to exacerbate conflict, so effective planning and coordination with security entities and potentially the fighting forces is necessary.

In Type 3 fragile future-risk states:

These states present a very different set of policy issues. While many are functional in terms of administration, and may or may not be experiencing active violence, they face a unique set of risks that can lead to future food insecurity and potentially conflict and violence. In these countries the focus should be on systemic resilience; for example, how robust are food reserves in case of a natural disaster, how effectively is food production managed so that dependence on imported staples is limited. With countries in this category the focus is less on food delivery and access, and more on putting in place policies and procedures that make the country's food supply resilient to global price and environmental shocks.

In non-functional conflict states:

In these situations, the conflict is so pervasive that there is no longer a functional government, and thus there is no data on what is driving food insecurity. While there is no administrative data, there is likely to be plenty of information in the media and from peacekeeping operations about where there are chronic food shortages. In these cases policy and operations should focus on coordinating with peacekeeping and humanitarian agencies to deliver needed food aid to violence-affected and besieged areas.[24]

[24] See Flores, Margarita (2004) "Conflicts, Rural Development and Food Security in West Africa," ESA Working Paper No. 04-02 for further analysis of post-conflict food access issues

Concluding Remarks

The cases and field analysis show that there has been a significant and necessary commitment to understanding the relationship between food security and conflict. Especially as conflict has become more complex, and our understanding of violence has expanded to include a wider range of phenomena, there is an increasingly wide space for conflict analysts to explore food security as a descriptive variable. On the food security side, given the wider range of violence that affects food insecure countries, understanding the political and social ways that food and food policy affect stability and peace are crucial for managing the unintended consequences of a new food security policy or program. While this is comparably easier to do using qualitative case analysis, an ongoing challenge that food security and conflict researchers will have to cooperatively address is the quality and quantity of data specifically looking at food security and conflict.

Something to keep in mind about the nature of food security and conflict data is that up to now much of the readily available data on both fields has not been designed to be analytically integrated. In the case of conflict data, it is more often than not representative of events at the at country/year level, so any other annualized data is challenging to place temporally in relation to an actual conflict event. Some of this is being alleviated by the disaggregated conflict datasets that were used in the case studies, which provide not only geographic detail, but also higher levels of precision about when events happened. As conflict event data becomes possible to produce at increasing levels of precision through new data capture technologies, it will be increasingly important for food security experts to be working with conflict experts to determine best practices for gathering food security-relevant conflict data. Because food security looks at relatively specific types of phenomena that are defined by medical conditions or standard economic indicators, it is important that the meta factors that underlie these variables be built into conflict data collection processes. For example, if we want to understand the impact of conflict on stunting, the conflict data collection process has to be designed in recognition that stunting is a long term effect; thus the conflict event data needs to have meta tags on location, date, and time, so that over time analysts can temporally and spatially match events multiple years apart.

This brings us to a key concept going forward, both for researchers and policy makers. The challenge for dealing with food security and conflict is not to find better ways to take two different things and compare them to each other. The challenge instead is to see them as one system; it will be necessary to see food security as peacebuilding and vice versa. Analytically we can only go so far using data that is designed to measure global patterns of food security, particularly since there are many cases where that data becomes unavailable when fighting breaks out in a country. The use of disaggregated data at the subnational level is a crucial starting point, and it will be increasingly important for people working on food security in the same countries as people working on conflict data to cooperate on data collection strategies to that the data is cohesive. This report has laid out some initial analytic starting points, demonstrating that undernourishment and other anthropometric food security indicators are highly impacted by different types of intrastate war, while food price and market insecurities are more strongly related to structural issues in how a country is governed. This helps identify were places need things like food delivery, and which countries can benefit from preventative policy measures in terms of food management. As longer timelines of global annualized data are captured, these can help identify the high-priority countries where new methods in sub-national data collection should be used to formulate context specific food security strategies. This will be made possible by efforts to quantitatively understand national contexts, new data streams, and an ongoing recognition that the best research and policy will be developed by multi-disciplinary teams of conflict and food security specialists.

Bibliography

2. The Complex Relationship Between Food Security and Conflict

Adhvaryu, Achyuta, and James Fenske. 2014. "Conflict and the Formation of Political Beliefs in Africa." *HiCN Working Paper 164*.

Adhvaryu, Achyuta, James Fenske, and Anant Nyshadham. 2016. "Early Life Circumstance and Mental Health in Ghana." *Working Paper*.

Adhvaryu, Achyuta, Namrata Kala, and Anant Nyshadham. 2015. "Booms, Busts, and Household Enterprise: Evidence from Coffee Farmers in Tanzania." *Working Paper*.

Akbulut-Yuksel, Mevlude. 2014. "Children of War." *Journal of Human Resources* 49 (3): 634–62. doi:10.3368/jhr.49.3.634.

Akresh, Richard. 2016. "Climate Change , Conflict , and Children." In *The Future of Children*, 26:51–71.

Akresh, Richard, Sonia Bhalotra, Marinella Leone, and Una Okonkwo Osili. 2012. "War and Stature: Growing Up during the Nigerian Civil War." *American Economic Review* 102 (3): 273–77.

Akresh, Richard, German Daniel Caruso, and Harsha Thirumurthy. 2016. "Detailed Geographic Information, Conflict Exposure, and Health Impacts." *HiCN Working Paper 238*.

Akresh, Richard, and Damien de Walque. 2008. "Armed Conflict and Schooling : Evidence from the 1994 Rwandan Genocide." *World Bank Policy Research Working Paper 4606*.

Akresh, Richard, Leonardo Lucchetti, and Harsha Thirumurthy. 2012. "Wars and Child Health: Evidence from the Eritrean–Ethiopian Conflict." *Journal of Development Economics* 99 (2): 330–40. doi:10.1016/j.jdeveco.2012.04.001.

Akresh, Richard, Philip Verwimp, and Tom Bundervoet. 2011. "Civil War, Crop Failure, and Child Stunting in Rwanda." *Economic Development and Cultural Change* 59 (4): 777–810. doi:10.1086/660003.

Alderman, Harold, John Hoddinott, and Bill Kinsey. 2006. "Long Term Consequences of Early Childhood Malnutrition." *Oxford Economic Papers* 58 (3): 450–74. doi:10.1093/oep/gpl008.

Almond, Douglas, and Janet Currie. 2011. "Killing Me Softly: The Fetal Origins Hypothesis." *Journal of Economic Perspectives* 25 (3): 153–72. doi:10.1016/j.surg.2006.10.010.Use.

Angrist, Joshua D, and Jörn-Steffen Pischke. 2010. "The Credibility Revolution in Empirical Economics: How Better Research Design Is Taking the Con out of Econometrics." *Journal of Economic Perspectives* 24 (2): 3–30. doi:10.1257/jep.24.2.3.

Arcand, Jean-Louis, Aude-Sophie Rodella, and Matthias Rieger. 2015. "The Impact of Land Mines on Child Health: Evidence from Angola." *Economic Development and Cultural Change* 63 (2): 249–79. doi:10.1086/679069.

Arcand, Jean-Louis, and Eric Dijimeu Wouabe. 2009. "Households in a Time of War: Instrumental

Variables Evidence for Angola." *Working Paper*.

Arezki, Rabah, and Markus Brueckner. 2014. "Effects of International Food Price Shocks on Political Institutions in Low-Income Countries: Evidence from an International Food Net-Export Price Index." *World Development* 61: 142–53. doi:10.1016/j.worlddev.2014.04.009.

Arias, Maria Alejandra, Ana Maria Ibañez, and Andrés Zambrano. 2012. "Agricultural Production Amid Conflict: The Effects of Shocks, Uncertainty, and Governance of Non-State Armed Actors." *Centro de Estudios Sobre Desarrollo Económico Paper*. doi:10.1017/CBO9781107415324.004.

Arjona, Ana, Nelson Kasfir, and Zachariah Mampilly. 2015. *Rebel Governance in Civil War*. Cambridge University Press.

Barnett, Jon, and W. Neil Adger. 2007. "Climate Change, Human Security and Violent Conflict." *Political Geography* 26 (6): 639–55. doi:10.1016/j.polgeo.2007.03.003.

Barrios, Salvador, Bazoumana Ouattara, and Eric Strobl. 2008. "The Impact of Climatic Change on Agricultural Production: Is It Different for Africa?" *Food Policy* 33 (4): 287–98. doi:10.1016/j.foodpol.2008.01.003.

Bauer, Michal, Christopher Blattman, Julie Chytilová, Joseph Henrich, Edward Miguel, and Tamar Mitts. 2016. "Can War Foster Cooperation?" *Journal of Economic Perspectives, Forthcoming*. doi:10.3386/w22312.

Baumann, Matthias, and Tobias Kuemmerle. 2016. "The Impacts of Warfare and Armed Conflict on Land Systems." *Journal of Land Use Science* 11 (6): 672–88. doi:10.1080/1747423X.2016.1241317.

Bazzi, Samuel, and Christopher Blattman. 2014. "Economic Shocks and Conflict: Evidence from Commodity Prices." *American Economic Journal: Macroeconomics* 6 (4): 1–38. doi:10.1257/mac.6.4.1.

Becker, Gary. 1968. "Crime and Punishment: An Economic Approach." *Journal of Political Economy* 76 (2): 169-2–17.

Bellemare, Marc F. 2015. "Rising Food Prices, Food Price Volatility, and Social Unrest." *American Journal of Agricultural Economics* 97 (1): 1–21. doi:10.1093/ajae/aau038.

Benjaminsen, T. A. 2008. "Does Supply-Induced Scarcity Drive Violent Conflicts in the African Sahel? The Case of the Tuareg Rebellion in Northern Mali." *Journal of Peace Research* 45 (6): 819–36. doi:10.1177/0022343308096158.

Berazneva, Julia, and David R. Lee. 2013. "Explaining the African Food Riots of 2007-2008: An Empirical Analysis." *Food Policy* 39: 28–39. doi:10.1016/j.foodpol.2012.12.007.

Blattman, Christopher, and Jeannie Annan. 2010. "The Consequences of Child Soldiering." *Review of Economics and Statistics* 92 (4): 882–98. doi:10.1162/REST_a_00036.

Blattman, Christopher, and Edward Miguel. 2010. "Civil War." *Journal of Economic Literature* 48 (1): 3–57.

Bohra-Mishra, Pratikshya, Michael Oppenheimer, and Solomon M Hsiang. 2014. "Nonlinear

Permanent Migration Response to Climatic Variations but Minimal Response to Disasters." *PNAS* 111 (27). National Academy of Sciences: 9780–85. doi:10.1073/pnas.1317166111.

Bollfrass, Alexander, and Andrew Shaver. 2015. "The Effects of Temperature on Political Violence: Global Evidence at the Subnational Level." *PLoS ONE* 10 (5): e0123505. doi:10.1371/journal.pone.0123505.

Bove, Vincenzo, Leandro Elia, and Ron P Smith. 2016. "On the Heterogeneous Consequences of Civil War." *Oxford Economic Papers* 1–19. doi:10.1093/oep/gpw050.

Bozzoli, Carlos, and Tilman Brück. 2009. "Agriculture, Poverty, and Postwar Reconstruction: Micro-Level Evidence from Northern Mozambique." *Journal of Peace Research* 46 (3): 377–97. doi:10.1177/0022343309102658.

Bozzoli, Carlos, Tilman Brück, and Tony Muhumuza. 2016. "Activity Choices of Internally Displaced Persons and Returnees: Quantitative Survey Evidence from Post-War Northern Uganda." *Bulletin of Economic Research* 68 (4): 329–47.

Bozzoli, Carlos, Tilman Brück, and Nina Wald. 2013a. "Evaluating Programmes in Conflict-Affected Areas." In *A Micro-Level Perspective on the Dynamics of Conflict, Violence and Development.*, edited by Patricia Justino, Tilman Brück, and Philip Verwimp. Oxford: Oxford University Press.

———. 2013b. "Self-Employment and Conflict in Colombia." *Journal of Conflict Resolution* 57 (1): 117–42.

Brakman, Steven, Harry Garretsen, and Marc Schramm. 2004. "The Strategic Bombing of German Cities during World War II and Its Impact on City Growth." *Journal of Economic Geography* 4 (2): 201–18. doi:10.1093/jeg/4.2.201.

Bratti, Massimiliano, Mariapia Mendola, and Alfonso Miranda. 2016. "Hard to Forget: The Long-Lasting Impact of War on Mental Health." *HiCN Working Paper 206*.

Breisinger, Clemens, Oliver Ecker, Jean-François Maystadt, Jean-François Trinh Tan, Perrihan Al-Riffai, Khalida Bouzar, Abdelkarim Sma, and Mohamed Abdelgadir. 2014. "Building Resilience To Conflict Through Food-Security Policies and Programs." *2020 Conference Paper 3*.

Breisinger, Clemens, Olivier Ecker, and Jean-François Trinh Tan. 2015. "Conflict and Food Security: How Do We Break the Links?" In *2014-2015 Global Food Policy Report*.

Brown, Ryan. 2015. "The Mexican Drug War and Early-Life Health : The Impact of Violent Crime on Birth Outcomes." *Working Paper*.

Brück, Tilman. 2003. "Investment in Land , Tenure Security and Area Farmed in Northern Mozambique." *HiCN Working Paper 1*.

Brück, Tilman, Neil T. N. Ferguson, Valeria Izzi and Wolfgang Stojetz. 2016. "Jobs Aid Peace: A Review of the Theory and Practice of the Impact of Employment Programmes on Peace in Fragile and Conflict-affected Countries". 16 September, Report for ILO, PBSO, UNDP and WBG. ISDC, Berlin.

Brück, Tilman, Patricia Justino, Philip Verwimp, Alexandra Avdeenko, and Andrew Tedesco. 2016. "Measuring Violent Conflict in Micro-Level Surveys: Current Practices and Methodological Challenges." *World Bank Research Observer* 31 (1): 29–58. doi:10.1093/wbro/lkv011.

Brück, Tilman, and Kati Schindler. 2009. "The Impact of Violent Conflicts on Households: What Do We Know and What Should We Know about War Widows?" *Oxford Development Studies* 37 (3). TF : 289–309. doi:10.1080/13600810903108321.

Buhaug, Halvard. 2010a. "Climate Not to Blame for African Civil Wars." *PNAS* 107 (38): 16477–82. doi:10.1073/pnas.1005739107.

———. 2010b. "Reply to Burke et Al.: Bias and Climate War Research." *PNAS* 107 (51): E186–87. doi:10.1073/pnas.1015796108.

Buhaug, Halvard, Tor A Benjaminsen, Espen Sjaastad, and Ole Magnus Theisen. 2015. "Climate Variability, Food Production Shocks, and Violent Conflict in Sub-Saharan Africa." *Environmental Research Letters* 10 (12). IOP Publishing: 125015. doi:10.1088/1748-9326/10/12/125015.

Bundervoet, Tom, Philip Verwimp, and Richard Akresh. 2009. "Health and Civil War in Rural Burundi." *Journal of Human Resources* 44 (2): 536–63. doi:10.1353/jhr.2009.0000.

Burke, Marshall B., John Dykema, David Lobell, Edward Miguel, and Shanker Satyanath. 2010. "Climate and Civil War: Is the Relationship Robust?" *NBER Working Paper 16440*.

Burke, Marshall B., Solomon M. Hsiang, and Edward Miguel. 2015. "Climate and Conflict." *Annual Review of Economics*, no. 7: 577–617. doi:10.1080/03071849008445480.

Burke, Marshall B., Edward Miguel, Shanker Satyanath, John A. Dykema, and David B. Lobell. 2009. "Warming Increases the Risk of Civil War in Africa." *PNAS* 106 (49): 20670–74. doi:10.1073/pnas.0907998106.

Burke, Marshall B., Edward Miguel, Shanker Satyanath, John A Dykema, and David B Lobell. 2010a. "Climate Robustly Linked to African Civil War." *PNAS* 107 (51): E185. doi:10.1073/pnas.1014879107.

Burke, Marshall B., Edward Miguel, Shanker Satyanath, John Dykema, and David Lobell. 2010b. "Reply to Sutton et Al.: Relationship between Temperature and Conflict Is Robust." *PNAS* 107 (25): E103–E103. doi:10.1073/pnas.1005748107.

Cadoret, Isabelle, Marie-Hélène Hubert, and Véronique Thelen. 2015. "Civil Conflicts and Food Price Spikes." *Working Paper*.

Camacho, Adriana. 2008. "Stress and Birth Weight: Evidence from Terrorist Attacks." *American Economic Review* 98 (2): 511–15. doi:10.1257/aer.98.2.511.

Carleton, Tamma A., and Solomon M. Hsiang. 2016. "Social and Economic Impacts of Climate." *Science* 353 (6304): aad9837-1-aad9837-12. doi:10.1126/science.aad9837.

Chamarbagwala, Rubiana, and Hilcías E. Morán. 2011. "The Human Capital Consequences of Civil War: Evidence from Guatemala." *Journal of Development Economics* 94 (1): 41–61.

doi:10.1016/j.jdeveco.2010.01.005.

Chen, Lincoln C., A. K. M. A. Chowdhury, and Sandra L. Huffman. 1980. "Anthropometric Assessment of Energy-Protein Malnutrition and Subsequent Risk of Mortality among Preschool Aged Children." *The American Journal of Clinical Nutrition* 33 (8): 1836–45.

Collier, Paul. 1999. "On the Economic Consequences of Civil War." *Oxford Economic Papers* 51 (1): 168–83. doi:10.1093/oep/51.1.168.

Collier, Paul, and Anke Hoeffler. 1998. "On Economic Causes of Civil War." *Oxford Economic Papers* 50 (4): 563–73. doi:10.1093/oep/50.4.563.

———. 2004. "Greed and Grievance in Civil War." *Oxford Economic Papers* 56 (4): 563–95. doi:10.1093/oep/gpf064.

Crost, Benjamin, Claire Duquennois, Joseph H. Felter, and Daniel I. Rees. 2015. "Climate Change, Agricultural Production and Civil Conflict: Evidence from the Phillipines." *IZA Discussion Paper 8965*.

Crost, Benjamin, Joseph Felter, and Patrick B Johnston. 2014. "Aid Under Fire: Development Projects and Civil Conflict." *American Economic Review* 104 (6): 1833–56. doi:10.1257/aer.104.6.1833.

Currie, Janet, and Tom Vogl. 2013. "Early-Life Health and Adult Circumstance in Developing Countries." *Annual Review of Economics* 5: 1–36. doi:10.1146/annurev-economics-081412-103704.

D'Souza, Anna, and Dean Jolliffe. 2013. "Conflict, Food Price Shocks, and Food Insecurity: The Experience of Afghan Households." *Food Policy* 42: 32–47. doi:10.1016/j.foodpol.2013.06.007.

Dabalen, Andrew L., and Saumik Paul. 2014. "Effect of Conflict on Dietary Diversity: Evidence from Côte d'Ivoire." *World Development* 58: 143–58. doi:10.1016/j.worlddev.2014.01.010.

Davis, Donald R, and David E Weinstein. 2002. "Bones, Bombs, and Break Points: The Geography of Economic Activity." *American Economic Review* 92 (5): 1269–89. doi:10.1257/000282802762024502.

de Groot, Olaf J, Carlos Bozzoli, and Tilman Brück. 2015. "The Global Economic Burden of Violent Conflict." *HiCN Working Paper 199*.

Deaton, Angus. 1999. "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives* 13 (3): 23–40. doi:10.1257/jep.13.3.23.

de Walque, Damien. 2006. "The Socio-Demographic Legacy of the Khmer Rouge Period in Cambodia." *Population Studies* 60 (2): 223–31. doi:10.1080/00324720600684767.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. 2014. "What Do We Learn from the Weather? The New Climate-Economy Literature." *Journal of Economic Literature* 52 (3): 740–98. doi:10.1257/jel.52.3.740.

Dell, Melissa, and Pablo Querubin. 2016. "Bombing the Way to State-Building? Lessons from the Vietnam War." *Working Paper*.

Demeke, Abera Birhanu, Alwin Keil, and Manfred Zeller. 2011. “Using Panel Data to Estimate the Effect of Rainfall Shocks on Smallholders Food Security and Vulnerability in Rural Ethiopia.” *Climatic Change* 108 (1–2). Springer Netherlands: 185–206. doi:10.1007/s10584-010-9994-3.

Dercon, Stefan, and Pramila Krishnan. 2000. “Vulnerability, Seasonality and Poverty in Ethiopia.” *Journal of Development Studies* 36 (6): 25–53. doi:10.1080/00220380008422653.

Di Falco, Salvatore, Marcella Veronesi, and Mahmud Yesuf. 2011. “Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective from Ethiopia.” *American Journal of Agricultural Economics* 93 (3): 825–42. doi:10.1093/ajae/aar006.

Diamond, Jared. 2005. *Collapse: How Societies Choose to Fail or Succeed.* Penguin Books.

Domingues, Patrick, and Thomas Barre. 2013. “The Health Consequences of the Mozambican Civil War: An Anthropometric Approach.” *Economic Development and Cultural Change* 61 (4): 755–88. doi:10.1086/670377.

Draca, Mirko, and Stephen Machin. 2015. “Crime and Economic Incentives.” *Annual Review of Economics* 7 (1). Annual Reviews: 389–408. doi:10.1146/annurev-economics-080614-115808.

Dube, Oeindrila, and Suresh Naidu. 2014. “Bases, Bullets and Ballots: The Effect of U.S. Military Aid on Political Conflict in Colombia.” *NBER Working Paper 20213*. doi:10.3386/w20213.

Dube, Oendrila, and Juan Vargas. 2013. “Commodity Price Shocks and Civil Conflict: Evidence from Colombia.” *The Review of Economic Studies* 80 (4): 1384–1421. doi:10.1093/restud/rdt009.

Duque, Valentina. 2016. “Early-Life Conditions , Parental Investments , and Child Development : Evidence from a Violent Conflict.” *Working Paper*. doi:10.1016/j.ssmph.2016.09.012.

Ehrlich, Isaac. 1973. “Participation in Illegitimate Activities: A Theoretical and Empirical Investigation.” *Journal of Political Economy* 81 (3): 521–65.

Feng, Shuaizhang, Alan B Krueger, and Michael Oppenheimer. 2010. “Linkages among Climate Change, Crop Yields and Mexico-US Cross-Border Migration.” *PNAS* 107 (32). National Academy of Sciences: 14257–62. doi:10.1073/pnas.1002632107.

Feng, Shuaizhang, Michael Oppenheimer, and Wolfram Schlenker. 2012. “Climate Change, Crop Yields, and Internal Migration in the United States.” *NBER Working Paper 17734*, 1–43. doi:10.3386/w17734.

Fernández, Manuel, Ana María Ibañez, and Ximena Peña. 2014. “Adjusting the Labor Supply to Mitigate Violent Shocks: Evidence from Rural Colombia.” *Journal of Development Studies* 50 (8): 1135–55. doi:10.1080/00220388.2014.919384.

Fiala, Nathan. 2015. “Economic Consequences of Forced Displacement.” *Journal of Development Studies* 51 (10): 1275–93. doi:10.1080/00220388.2015.1046446.

Fjelde, Hanne. 2015. “Farming or Fighting? Agricultural Price Shocks and Civil War in Africa.” *World Development* 67: 525–34. doi:10.1016/j.worlddev.2014.10.032.

Floreani, Vincent A., Gladys López-Acevedo, and Martín Rama. 2016. "Conflict and Poverty in Afghanistan's Transition." *HiCN Working Paper 234*.

Foureaux Koppensteiner, Martin, and Marco Manacorda. 2016. "Violence and Birth Outcomes: Evidence from Homicides in Brazil." *Journal of Development Economics* 119 (3): 16–33. doi:10.1016/j.jdeveco.2015.11.003.

Fuchs-Schündeln, Nicola, and Tarek Alexander Hassan. 2015. "Natural Experiments in Macroeconomics." *NBER Working Paper 21228*. doi:10.1017/CBO9781107415324.004.

Gáfaro, Margarita, Ana María Ibáñez, and Patricia Justino. 2014. "Local Institutions and Armed Group Presence in Coolombia." *HiCN Working Paper 178*.

Gates, Scott, Håvard Hegre, Håvard Mokleiv Nygård, and Håvard Strand. 2012. "Development Consequences of Armed Conflict." *World Development* 40 (9): 1713–22. doi:10.1016/j.worlddev.2012.04.031.

Ghimire, Ramesh, Susana Ferreira, and Jeffrey H. Dorfman. 2015. "Flood-Induced Displacement and Civil Conflict." *World Development* 66: 614–28. doi:10.1016/j.worlddev.2014.09.021.

Gleditsch, N. P. 2012. "Whither the Weather? Climate Change and Conflict." *Journal of Peace Research* 49 (1): 3–9. doi:10.1177/0022343311431288.

Goldstone, Jack A. 1991. *Revolution and Rebellion in the Early Modern World.* Los Angeles, CA: University of California Press.

Groce, Nora, Sophie Mitra, Daniel Mont, Cuong Nguyen, and Michael Palmer. 2016. "The Long-Term Impact of War: Evidence on Disability Prevalence in Vietnam." *UCL Leonard Cheshire Disability and Inclusive Development Centre Working Paper 28*.

Guardado, Jenny, and Steven Pennings. 2016. "The Seasonality of Conflict." *Working Paper*.

Guerrero-Serdan, Gabriela. 2009. "The Effects of the War in Iraq on Nutrition and Health: An Analysis Using Anthropometric Outcomes of Children." *HiCN Working Paper 55*.

Guiteras, Raymond, and Ahmed Mushfiq Mobarak. 2015. "Does Development Aid Undermine Political Accountability? Leader and Constituent Responses to a Large-Scale Intervention." *NBER Working Paper 21434*. doi:10.3386/w21434.

Gurr, Ted R. 1970. *Why Men Rebel*. Princeton, NJ: Princeton University Press.

Hendrix, Cullen, and Henk-Jan Brinkman. 2013. "Food Insecurity and Conflict Dynamics: Causal Linkages and Complex Feedbacks." *Stability: International Journal of Security & Development* 2 (2): 26. doi:10.5334/sta.bm.

Hendrix, Cullen S., Stephan Haggard, and Beatriz Magaloni. 2009. "Grievance and Opportunity: Food Prices, Political Regime, and Protest." *Conference Paper at the International Studies Association Convention 2009*.

Hendrix, Cullen S., and Idean Salehyan. 2012. "Climate Change, Rainfall, and Social Conflict in Africa." *Journal of Peace Research* 49 (1): 35–50. doi:10.1177/0022343311426165.

Hidalgo, F. Daniel, Suresh Naidu, Simeon Nichter, and Neal Richardson. 2010. "Economic

Determinants of Land Invasions." *Review of Economics and Statistics* 92 (3): 505–23. doi:10.1162/REST_a_00007.

Hirshleifer, Jack. 2001. *The Dark Side of the Force: Economic Foundations of Conflict Theory*. Cambridge: Cambridge University Press.

Homer-Dixon, Thomas F. 1999. *Environment, Scarcity, and Violence*. Princeton, NJ: Princeton University Press.

Hsiang, Solomon M. 2010. "Temperatures and Cyclones Strongly Associated with Economic Production in the Caribbean and Central America." *PNAS* 107 (35). National Academy of Sciences: 15367–72. doi:10.1073/pnas.1009510107.

Hsiang, Solomon M., Marshall B. Burke, and Edward Miguel. 2013. "Quantifying the Influence of Climate on Human Conflict." *Science* 341 (6151): 1235367. doi:10.1126/science.1235367.

Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane. 2011. "Civil Conflicts Are Associated with the Global Climate." *Nature* 476 (7361): 438–41. doi:10.1038/nature10311.

Humphreys, Macartan, and Jeremy M. Weinstein. 2008. "Who Fights? The Determinants of Participation in Civil War." *American Journal of Political Science* 52 (2): 436–55. doi:10.1111/j.1540-5907.2008.00322.x.

Jakiela, Pamela, and Owen W. Ozier. 2016. "The Impact of Violence on Individual Risk Preferences: Evidence from a Natural Experiment." *IZA Discussion Paper 9870*.

Jeanty, Pierre Wilner, and Fred Hitzhusen. 2006. "Analyzing the Effects of Conflicts on Food Security in Developing Countries: An Instrumental Variable Panel Data Approach." *Conference Paper at the American Agricultural Economics Association Annual Meeting 2006*.

Jia, Ruixue. 2014. "Weather Shocks, Sweet Potatoes and Peasant Revolts in Historical China." *The Economic Journal* 124 (575): 92–118. doi:10.1111/ecoj.12037.

Johnstone, Sarah, and Jeffrey Mazo. 2011. "Global Warming and the Arab Spring." *Global Politics and Strategy* 53 (2): 11–17. doi:10.1080/00396338.2011.571006.

Jones, Benjamin F, and Benjamin A Olken. 2010. "Climate Shocks and Exports." *American Economic Review* 100 (2): 454–59.

Justino, Patricia. 2009. "The Impact of Armed Civil Conflict on Household Welfare and Policy Responses." *HiCN Working Paper 61*.

———. 2010. "War and Poverty." *HiCN Working Paper 81*.

———. 2012. "Nutrition, Governance and Violence: A Framework for the Analysis of Resilience and Vulnerability to Food Insecurity in Contexts of Violent Conflict." *HiCN Working Paper 132*.

Justino, Patricia, and Wolfgang Stojetz. 2016. "On the Legacies of Wartime Governance." *Working Paper*.

Kalyvas, Stathis N. 2006. *The Logic of Violence in Civil War*. Cambridge: Cambridge University

Press.

Kalyvas, Stathis N., and Matthew A. Kocher. 2007. "How 'Free' Is Free Riding in Civil Wars?: Violence, Insurgency, and the Collective Action Problem." *World Politics* 59 (2): 177–216.

Keen, David. 1998. *The Economic Functions of Violence in Civil Wars*. Oxford University Press for the International Institute for Strategic Studies.

Kelley, Colin P, Shahrzad Mohtadi, Mark A Cane, Richard Seager, and Yochanan Kushnir. 2015. "Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought." *PNAS* 112 (11). National Academy of Sciences: 3241–46. doi:10.1073/pnas.1421533112.

Kim, N. K. 2016. "Revisiting Economic Shocks and Coups." *Journal of Conflict Resolution* 60 (1): 3–31. doi:10.1177/0022002713520531.

Kondylis, Florence. 2010. "Conflict Displacement and Labor Market Outcomes in Post-War Bosnia and Herzegovina." *Journal of Development Economics* 93 (2): 235–48. doi:10.1016/j.jdeveco.2009.10.004.

Koren, Ore, and Benjamin E. Bagozzi. 2016. "From Global to Local, Food Insecurity Is Associated with Contemporary Armed Conflicts." *Food Security*. doi:10.1007/s12571-016-0610-x.

Kruger, Diana I. 2007. "Coffee Production Effects on Child Labor and Schooling in Rural Brazil." *Journal of Development Economics* 82 (2): 448–63. doi:10.1016/j.jdeveco.2006.04.003.

La Ferrara, Eliana, and Mariaflavia Harari. 2015. "Conflict, Climate and Cells : A Disaggregated Analysis." *Working Paper*.

Lagi, Marco, Karla Z. Bertrand, and Yaneer Bar-Yam. 2011. "The Food Crises and Political Instability in North Africa and the Middle East." *SSRN Working Paper*. doi:10.2139/ssrn.1910031.

Lopez, H., and Quentin Wodon. 2005. "The Economic Impact of Armed Conflict in Rwanda." *Journal of African Economies* 14 (4): 586–602. doi:10.1093/jae/eji021.

Lozano, Rafael, Mohsen Naghavi, Kyle Foreman, Stephen Lim, Kenji Shibuya, Victor Aboyans, Jerry Abraham, et al. 2012. "Global and Regional Mortality from 235 Causes of Death for 20 Age Groups in 1990 and 2010: A Systematic Analysis for the Global Burden of Disease Study 2010." *The Lancet* 380 (9859): 2095–2128. doi:10.1016/S0140-6736(12)61728-0.

Maccini, Sharon, and Dean Yang. 2009. "Under the Weather : Health , Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review* 99 (3): 1006–26. doi:10.1257/aer.99.3.1006.

Maertens, Ricardo. 2016. "Adverse Rainfall Shocks and Civil War : Myth or Reality ?" *HiCN Working Paper 212*.

Manacorda, Marco, Edward Miguel, and Andrea Vigorito. 2011. "Government Transfers and Political Support." *American Economic Journal: Applied Economics* 3 (3): 1–28. doi:10.1257/app.3.3.1.

Mansour, Hani, and Daniel I. Rees. 2012. "Armed Conflict and Birth Weight: Evidence from the Al-Aqsa Intifada." *Journal of Development Economics* 99 (1): 190–99.

doi:10.1016/j.jdeveco.2011.12.005.

Martinez-Cruz, Adan L., and Carlos Rodríguez-Castelán. 2016. "Crime and Persistent Punishment: A Long-Run Perspective on the Links between Violence and Chronic Poverty in Mexico." *World Bank Policy Research Working Paper 7706*.

Maystadt, Jean-François, and Olivier Ecker. 2014. "Extreme Weather and Civil War: Does Drought Fuel Conflict in Somalia through Livestock Price Shocks?" *American Journal of Agricultural Economics* 96 (4): 1157–82. doi:10.1093/ajae/aau010.

Maystadt, Jean-François, Jean-François Trinh Tan, and Clemens Breisinger. 2014. "Does Food Security Matter for Transition in Arab Countries?" *Food Policy* 46: 106–15. doi:10.1016/j.foodpol.2014.01.005.

McGuirk, Eoin, and Marshall B. Burke. 2016. "Economic Shocks and Varieties of Conflict: Global Prices, Real Income and Local Violence in Africa." *Working Paper*.

Menon, Nidhiya, and Yana van der Meulen Rodgers. 2015. "War and Women's Work: Evidence from the Conflict in Nepal." *Journal of Conflict Resolution* 59 (1): 51–73. doi:10.1177/0022002713498699.

Merrouche, Ouarda. 2008. "Landmines and Poverty: IV Evidence from Mozambique." *Peace Economics, Peace Science and Public Policy* 14 (1): Article 2.

Messer, Ellen, and Marc J. Cohen. 2015. "Breaking the Links between Conflict and Hunger Redux." *World Medical and Health Policy* 7 (3): 211–33. doi:10.1002/wmh3.147.

Miguel, Edward, and Gérard Roland. 2011. "The Long-Run Impact of Bombing Vietnam." *Journal of Development Economics* 96 (1): 1–15. doi:10.1016/j.jdeveco.2010.07.004.

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. 2004. "Economic Shocks and Civil Conflict: An Instrumental Variables Approach." *Journal of Political Economy* 112 (4): 725–53.

Miller, Grant, and B Piedad Urdinola. 2010. "Cyclicality, Mortality, and the Value of Time: The Case of Coffee Price Fluctuations and Child Survival in Colombia." *Journal of Political Economy* 118 (1): 113–55.

Minoiu, Camelia, and Olga N. Shemyakina. 2014. "Armed Conflict, Household Victimization, and Child Health in Côte d'Ivoire." *Journal of Development Economics* 108: 237–55. doi:10.1016/j.jdeveco.2014.03.003.

Munoz-Mora, Juan Carlos. 2016. "Fighting While ' Talking ': Assessing the Impact of Civil War on Agriculture." *Working Paper*.

Nasir, Muhammad. 2016. "Violence and Child Health Outcomes: Evidence from the Mexican Drug War." *HiCN Working Paper 208*.

NEPAD. 2013. "Agriculture in Africa: Transformation and Outlook." *New Partnership for African Development*.

Nillesen, Eleonora. 2007. "Empty Cups ? Assessing the Impact of Civil War Violence on Coffee Farming in Burundi." *African Journal of Agricultural and Resource Economics* 11 (1): 69–

83.

Nillesen, Eleonora, and Philip Verwimp. 2010. “A Phoenix in Flames? Portfolio Choice and Violence in Civil War in Rural Burundi.” *HiCN Working Paper 75*. doi:10.2139/ssrn.1650246.

Nunn, Nathan, and Nancy Qian. 2014. “US Food Aid and Civil Conflict.” *American Economic Review* 104 (6): 1630–66.

Ogbozor, Ernest. 2016. “Resilience to Violent Extremism: The Rural Livelihood Coping Strategies in the Lake Chad Basin.” *HiCN Working Paper 237*.

Palmer, Michael, Cuong Nguyen, Sophie Mitra, Daniel Mont, and Nora Groce. 2016. “The Long-Term Impact of War on Health.” *HiCN Working Paper 216*.

Parlow, Anton. 2012. “Armed Conflict and Children’s Health – Exploring New Directions: The Case of Kashmir.” *HiCN Working Paper 119*.

Paul, Saumik, Abu S Shonchoy, and Andrew Dabalen. 2015. “Food Crop Diversification as a Risk Mitigating Strategy during Conflict : Evidence from Cote d’Ivoire.” *Insitute of Developing Economies Discussion Paper 496*.

Puri, Jyotsna, Anastasia Aladysheva, Vegard Iversen, Yashodhan Ghorpade, and Tilman Brück. 2014. “What Methods May Be Used in Impact Evaluations of Humanitarian Assistance?” *HiCN Working Paper 193*.

Raleigh, Clionadh. 2010. “Political Marginalization, Climate Change, and Conflict in African Sahel States.” *International Studies Review* 12 (1): 69–86. doi:10.1111/j.1468-2486.2009.00913.x.

Raleigh, Clionadh, Hyun Jin Choi, and Dominic Kniveton. 2015. “The Devil Is in the Details: An Investigation of the Relationships between Conflict, Food Price and Climate across Africa.” *Global Environmental Change* 32: 187–99. doi:10.1016/j.gloenvcha.2015.03.005.

Raleigh, Clionadh, and Dominic Kniveton. 2012. “Come Rain or Shine: An Analysis of Conflict and Climate Variability in East Africa.” *Journal of Peace Research* 49 (1): 51–64. doi:10.1177/0022343311427754.

Ray, Debraj, and Joan Esteban. 2016. “Conflict and Development.” *Annual Review of Economics* Forthcomin.

Reuveny, Rafael. 2007. “Climate Change-Induced Migration and Violent Conflict.” *Political Geography* 26 (6): 656–73. doi:10.1016/j.polgeo.2007.05.001.

Rockmore, Marc. 2011. “The Cost of Fear: The Welfare Effects of the Risk of Violence in Northern Uganda.” *HiCN Working Paper 109*.

———. 2015. “Conflict and Agricultural Portfolios: Evidence from Northern Uganda.” *Working Paper*.

Rockmore, Marc, Christopher B. Barrett, and Jeannie Annan. 2016. “An Empirical Exploration of the Near-Term and Persistent Effects of Conflict on Risk Preferences.” *HiCN Working Paper 239*.

Rudé, George. 1964. *The Crowd in History: A Study of Popular Disturbances in France and England, 1730-1848*. New York: Wiley.

Ruiz, Isabel, and Carlos Vargas-Silva. 2013. "The Economics of Forced Migration." *Journal of Development Studies* 49 (6): 772–84. doi:10.1080/00220388.2013.777707.

———. 2015. "The Labor Market Impacts of Forced Migration." *American Economic Review* 105 (5): 581–86. doi:10.1257/aer.p20151110.

Salehyan, Idean, and Kristian Skrede Gleditsch. 2006. "Refugees and the Spread of Civil War." *International Organization* 60 (2): 335–66. doi:10.1017/S0020818306060103.

Sanchez de la Sierra, Raul. 2016. "On the Origin of States: Stationary Bandits and Taxation in Eastern Congo." *SSRN Working Paper*. doi:10.2139/ssrn.2358701.

Schlenker, Wolfram, and David B. Lobell. 2010. "Robust Negative Impacts of Climate Change on African Agriculture." *Environmental Research Letters* 5 (1). IOP Publishing: 14010. doi:10.1088/1748-9326/5/1/014010.

Serneels, Pieter, and Marijke Verpoorten. 2015. "The Impact of Armed Conflict on Economic Performance: Evidence from Rwanda." *Journal of Conflict Resolution* 59 (4): 555–92. doi:10.1177/0022002713515409.

Shemyakina, Olga. 2011. "The Effect of Armed Conflict on Accumulation of Schooling: Results from Tajikistan." *Journal of Development Economics* 95 (2): 186–200. doi:10.1016/j.jdeveco.2010.05.002.

Smith, Todd G. 2014. "Feeding Unrest: Disentangling the Causal Relationship between Food Price Shocks and Sociopolitical Conflict in Urban Africa." *Journal of Peace Research* 51 (6): 679–95. doi:10.1177/0022343314543722.

Sutton, Alexandra E, Justin Dohn, Kara Loyd, Andrew Tredennick, Gabriela Bucini, Alexandro Solórzano, Lara Prihodko, and Niall P Hanan. 2010. "Does Warming Increase the Risk of Civil War in Africa?" *PNAS* 107 (25): E102; author reply E103. doi:10.1073/pnas.1005278107.

Teodosijević, Slobodanka. 2003. "Armed Conflicts and Food Security." 03–11. *ESA Working Paper*. ftp://193.43.36.93/docrep/fao/007/ae044e/ae044e00.pdf.

Theisen, Ole M. 2012. "Climate Clashes? Weather Variability, Land Pressure, and Organized Violence in Kenya, 1989-2004." *Journal of Peace Research* 49 (1): 81–96. doi:10.1177/0022343311425842.

Theisen, Ole M., Helge Holtermann, and Halvard Buhaug. 2011. "Climate Wars? Assessing the Claim That Drought Breeds Conflict." *International Security* 36 (3): 79–106.

Tilly, Charles. 1978. *From Mobilization to Revolution*. Addison-Wesley Publishing Company.

Townsend, Robert M. 1994. "Risk and Insurance in Village India." *Econometrica* 62 (3): 539. doi:10.2307/2951659.

Tranchant, Jean-Pierre, Patricia Justino, and Catherine Müller. 2014. "Political Violence, Drought and Child Malnutrition: Empirical Evidence from Andhra Pradesh, India." *HiCN Working*

Paper 173.

Tusiime, Hamidu A., Robrecht Renard, and Lodewijk Smets. 2013. "Food Aid and Household Food Security in a Conflict Situation: Empirical Evidence from Northern Uganda." *Food Policy* 43: 14–22. doi:10.1016/j.foodpol.2013.07.005.

Valente, Christine. 2011. "Children of the Revolution: Fetal and Child Health amidst Violent Civil Conflict." *Working Paper*.

Van Weezel, Stijn. 2016. "Food Imports, International Prices, and Violence in Africa." *Oxford Economic Papers* 68 (3): 758–81. doi:10.1093/oep/gpw015.

Vanden Eynde, Oliver. 2015. "Targets of Violence: Evidence from India's Naxalite Conflict." *The Economic Journal* Forthcomin. doi:10.1111/ecoj.12.

Verpoorten, Marijke. 2009. "Household Coping in War- and Peacetime: Cattle Sales in Rwanda, 1991–2001." *Journal of Development Economics* 88 (1): 67–86. doi:10.1016/j.jdeveco.2008.01.003.

Verwimp, Philip. 2012. "Undernutrition, Subsequent Risk of Mortality and Civil War in Burundi." *Economics and Human Biology* 10 (3): 221–31. doi:10.1016/j.ehb.2011.09.007.

Verwimp, Philip, and Juan Carlos Munoz-Mora. 2013. "Returning Home after Civil War: Food Security, Nutrition and Poverty among Burundian Households." *HiCN Working Paper 123*.

Vlassenroot, Koen. 2008. "Land Tenure, Conflict and Household Strategies in the Eastern Democratic Republic of the Congo." In *Beyond Relief: Food Security in Protracted Crises. FAO and Practical Action Publishing, Rugby, UK*, 197–221. doi:10.3362/9781780440057.

von Uexkull, Nina, Mihai Croicu, Hanne Fjelde, and Halvard Buhaug. 2016. "Civil Conflict Sensitivity to Growing-Season Drought." *PNAS* 113 (134): 201607542. doi:10.1073/pnas.1607542113.

Voors, Maarten J, Eleonora E M Nillesen, Philip Verwimp, Erwin H Bulte, By Maarten J Voors, Eleonora E M Nillesen, Philip Verwimp, Erwin H Bülte, Robert Lensink, and Daan P Van Soest. 2012. "Conflict and Behavior: A Field Experiment in Burundi." *American Economic Review* 102 (2): 941–64.

Vothknecht, Marc, and Sudarno Sumarto. 2011. "Beyond the Overall Economic Downturn: Evidence on Sector-Specific Effects of Violent Conflict from Indonesia." *DIW Berlin Discussion Paper 1105*.

Walter, Barbara F. 2004. "Does Conflict Beget Conflict? Explaining Recurring Civil War." *Journal of Peace Research* 41 (3): 371–88. doi:10.1177/0022343304043775.

Weinberg, Joe, and Ryan Bakker. 2015. "Let Them Eat Cake: Food Prices, Domestic Policy and Social Unrest." *Conflict Management and Peace Science* 32 (3): 309–26. doi:10.1177/0738894214532411.

Wischnath, Gerdis, and Halvard Buhaug. 2014. "Rice or Riots: On Food Production and Conflict Severity across India." *Political Geography* 43: 6–15. doi:10.1016/j.polgeo.2014.07.004.

Wood, Elisabeth Jean. 2003. *Insurgent Collective Action and Civil War in El Salvador*. Cambridge

Studies in Comparative Politics. New York: Cambridge University Press.

Wright, Austin L. 2016. "Economic Shocks and Rebel Tactics." *HiCN Working Paper 232*.

Young, Helen, and Susanne Jaspars. 2009. "Review of Nutrition and Mortality Indicators for the Integrated Food Security Phase Classification (IPC): Reference Levels and Decision-Making." http://www.odi.org/publications/4616-nutrition-mortality-indicators-integrated-food-security-phase-classification-ipc.

3. Food Security and Conflict: Analytic Framework and Typologies

Besley, Timothy and Torsten Persson 2014. "The Causes and Consequences of Development Clusters: State Capacity, Peace, and Income," *Annual Review of Economics.* 6: 927-949

Eck, Kristine and Lisa Hultmann 2007. "Violence Against Civilians in War," *Journal of Peace Research.* 44(2): 233-246

FAO 2015. "Peace and Food Security: Investing in resilience to sustain rural livelihoods amid conflict." FAO Technical Note

Flores, Margarita 2004. "Conflicts, Rural Development and Food Security in West Africa," ESA Working Paper No. 04-02

Melander, Erik, Frida Möller and Magnus Öberg 2009. "Managing Intrastate Low-Intensity Armed Conflict 1993-2004: A New Dataset," *International Interactions*, 35(1): 58-85

Messer, Ellen and Marc J. Cohen 2015. "Breaking the Links Between Conflict and Hunger Redux." *World Medical and Health Policy.* 7(3): 211-233

Pettersson, Therese and Peter Wallensteen 2015. "Armed Conflicts, 1946-2014," *Journal of Peace Research.* 52(4): 536-550

Stanton, Jessica 2015. "Regulating Militias: Governments, Militias, and Civilian Targeting in Civil War," *The Journal of Conflict Resolution*, 59(5): 899-923

Teodosijevic, Slobodanka 2003. "Armed Conflicts and Food Security," ESA Working Paper No. 03-11

van Weezel, Stijn 2016. "Food imports, international prices, and violence in Africa," *Oxford Economic Papers.* 68(3): 758-781

World Bank 2016. "Harmonized List of Fragile Situations," Available at: http://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonized-list-of-fragile-situations Accessed: 17 December, 2016

4. Estimating the Effect of Conflict on Food Supply at the National Level

Andersson, N., C. Palha da Sousa, and S. Paredes (1995). Social cost of land mines in four countries : Afghanistan , Bosnia, Cambodia, and Mozambique. British Medical Journal 721, 718–721.

Angrist, J. D. and Pischke (2008). Mostly Harmless Econometrics : An Empiricist ' s Companion. Number March.

Blaydes, L. and M. A. Kayser (2011). Counting Calories: Democracy and Distribution in the Developing World. International Studies Quarterly 55 (4), 887–908.

Brooks, S., A. Gelman, G. L. Jones, and X.-L. Meng (2011). Handbook of Markov Chain Monte Carlo. Chapman & Hall/CRC.

Brooks, S. P. and A. Gelman (1998). General methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics 7, 434–455.

Danneman, N. and E. H. Ritter (2014). Contagious Rebellion and Preemptive Repression. Journal of Conflict Resolution 58 (2), 254–279.

de Boef, S. and L. Keele (2008). Taking Time Seriously. American Journal of Agricultural Economics 52 (1), 184–200.

de Haen, H., S. Klasen, and M. Qaim (2011). What do we really know? Metrics for food insecurity and undernutrition. Food Policy 36 (6), 760–769.

FAO, IFAD, and WFP. (2015). The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress.

FAO Statistical Division (2016). http://faostat3.fao.org/faostat-gateway/go/to/home/E. (accessed 3 August 2016).

Gelman, A., J. B. Carlin, H. S. Stern, and D. B. Rubin (1995). Bayesian Data Analysis. Chapman & Hall/CRC.

Gleditsch, N. P., P. Wallensteen, M. Eriksson, M. Sollenberg, and H. Strand (2002). Armed Conflict 1946-2001: A New Dataset. Journal of Peace Research 39 (5), 615–637.

Goldstone, J., R. Bates, D. Epstein, T. R. Gurr, M. B. Lustik, M. G. Marshall, J. Ulfelder, and M. Woodward (2010). A global model for forecasting political instability. American Journal of Political Science 54 (1), 190–208.

Heston, A. (1994). A brief review of some problems in using national accounts data in level of output comparisons and growth studies. Journal of Development Economics 44 (1), 29–52.

Jerven, M. (2011). Growth, stagnation or retrogression? On the accuracy of economic observations, Tanzania, 1961-2001. Journal of African Economies 20 (3), 377–394.

Jerven, M. (2016). Africa by numbers: Reviewing the database approach to studying African economies. African Affairs 115 (459), 342–358.

Johnson, S., W. Larson, C. Papageorgiou, and A. Subramanian (2009). Is newer better? Penn World Table revisions and their impact on growth estimates.

Kalyvas, Stathis N. (2004). The urban bias in the research on civil wars, Volume 13.

Lacina, B. and N. P. Gleditsch (2005). Monitoring trends in global combat: A new dataset of battle deaths. European Journal of Population 21 (2-3), 145–166.

Maystadt, J. F., J. F. Trinh Tan, and C. Breisinger (2014). Does food security matter for transition in Arab countries? Food Policy 46, 106–115.

Messer, E. and M. J. Cohen (2015). Breaking the Links between Conflict and Hunger Redux. World Medical and Health Policy 7 (3), 211–233.

Pinstrup-Andersen, P. and S. Shimokawa (2008). Do poverty and poor health and nutrition increase the risk of armed conflict onset? Food Policy 33 (6), 513–520.

Plummer, M. (2014). JAGS: A Program for Analysis of Bayesian Graphical Models Using Gibbs Sampling. (Version 3.4.0).

Raleigh, C., a. Linke, H. Hegre, and J. Karlsen (2010). Introducing ACLED: An Armed Conflict Location and Event Dataset: Special Data Feature. Journal of Peace Research 47, 651–660.

Souza, A. D. and D. Jolliffe (2013). Conflict , food price shocks , and food insecurity : The experience of Afghan households. Food Policy 42, 32–47.

The Economist (2012). Protests in Nigeria: Let them have fuel. http://www.economist.com/node/21543199. (accessed 30 June 2012).

Tusiime, H. A., R. Renard, and L. Smets (2013). Food aid and household food security in a conflict situation : Empirical evidence from Northern Uganda. Food Policy 43, 14–22.

Unruh, J. D., N. C. Heynen, and P. Hossler (2003). The political ecology of recovery from armed conflict: The case of landmines in Mozambique. Political Geography 22 (8), 841–861.

Verpoorten, M., A. Arora, N. Stoop, and J. Swinnen (2013). Self-reported food insecurity in Africa during the food price crisis. Food Policy 39, 51–63.

Verwimp, Philip. (2005). An economic profile of peasant perpetrators of genocide. Micro-level evidence from Rwanda. Journal of Development Economics 77 (2), 297–323.

Wheeler, T. and J. von Braun (2013). Climate change impacts on global food security. Science (New York, N.Y.) 341 (6145), 508–13.

5. The Impact of Food Security on Conflict: Evidence from Ethiopia

Barrios, Salvador, Bazoumana Ouattara, and Eric Strobl. 2008. “The Impact of Climatic Change on Agricultural Production: Is It Different for Africa?” *Food Policy* 33(4): 287–98.

Buhaug, H, Kristian Skrede Gleditsch, Helge Holtermann, Gudrun Østby, and Andreas Forø Tollefsen. 2011. "It's the Local Economy, Stupid! Geographic Wealth Dispersion and Conflict Outbreak Location." *Journal of Conflict Resolution* 55(5): 814–40.

Buhaug, Halvard. 2010. "Climate Not to Blame for African Civil Wars." *Proceedings of the National Academy of Sciences of the United States of America* 107(38): 16477–82.

Burke, Marshall B, Edward Miguel, Shanker Satyanath, John A. Dykema, and David B. Lobell.2009. "Warming Increases the Risk of Civil War in Africa." *Proceedings of the National Academy of Sciences of the United States of America* 106(49): 20670–74.

Center for International Earth Science Information Network (CIESIN) and Centro Internacional de Agricultura Tropical (CIAT) (2005). *Gridded Population of the World, Version 3 (GPWv3): Population Count Grid*. Palisades, NY. doi:10.7927/H4639MPP. Accessed 03.06.2013.

Dell, M., B. Jones, and B. Olken. 2012. "Temperature Shocks and Economic growth: Evidence from the last Half Century." *American Economic Journal: Macroeconomics* 4 (3): 66–95.

Demeke, Abera, Alwin Keil, Manfred Zeller. 2011. "Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia" *Climate Change*, 108 (2011), pp. 185–206

Dercon, Stefan, and Pramila Krishnan. 2000. "Vulnerability, Seasonality and Poverty in Ethiopia." *Journal of Development Studies* 36(6): 25–53. http://www.tandfonline.com/doi/abs/10.1080/00220380008422653.

Di Falco, S, and M Veronesi. 2010. "On Adaptation to Climate Change and Food Security: A Micro-Perspective from Ethiopia." *CSAE Conference 2010: Economic Development in Africa* (22): 1–33.

Famine Early Warning Systems Network. 2011. "*Ethiopia Food Security July 2011 Update*"

Glantz, Michael. 1988. *Drought and Hunger in Africa,* Cambridge: Cambridge University Press

Hendrix Cullen, Idean Salehyan. 2012. "Climate change, rainfall, and social conflict in Africa." *Journal of Peace Research 49(1) 35–50*

Hsiang, Solomon M. 2010. "Temperatures and Cyclones Strongly Associated with Economic Production in the Caribbean and Central America." *Proceedings of the National Academy of Sciences of the United States of America* 107(35): 15367–72.

Hsiang, Solomon M, Marshall Burke, and Edward Miguel. 2013. "Quantifying the Influence of Climate on Human Conflict." *Science* 341(6151): 1235367.

IMF. 2014. Country Report No. 14/304, *The Federal Democratic Republic of Ethiopia, Selected Issues Paper*, 2014

King, Gary, and Langche Zeng. 2001. “Logistic Regression in Rare Events Data.” *Political analysis* 9(2): 137–63.

Lavers, Tom. 2012. “Land Grab as Development Strategy? The Political Economy of Agricultural Investment in Ethiopia.” *Journal of Peasant Studies* 39(1): 37–41. http://dx.doi.org/10.1080/03066150.2011.652091.

Maystadt, Jean François, and Olivier Ecker. 2014. “Extreme Weather and Civil War: Does Drought Fuel Conflict in Somalia through Livestock Price Shocks?” *American Journal of Agricultural Economics* 96(4): 1157–82.

Meiyappan, Prasanth and Atul K. Jain (2012). Three distinct global estimates of historical land-cover change and land-use conversions for over 200 years. *Frontiers of Earth Science*, 6(2), 122-139. doi: 10.1007/s11707-012-0314-2.

Miguel, Edward, Shanker Satyanath , and Ernest Sergenti. 2004. “Economic Shocks and Civil Conflict : An Instrumental Variables Approach” *Journal of Political Economy*, vol. 112, no. 4

Nordhaus, William D. (2006) Geography and macroeconomics: New data and new findings. *Proceedings of the National Academy of Sciences of the USA*, 103(10): 3510-3517.

O’Loughlin, John, Frank Linke, Andrew Witmer, Arlene Laing, Andrew Gettelman and Jimy Dudhia. 2012. “Climate Variability and Conflict Risk in East Africa” *Proceedings of the National Academy of Sciences of the United States of America*: vol (109)

Raleigh, Clionadh, Andrew Linke, Håvard Hegre and Joakim Karlsen. 2010. Introducing ACLED-Armed Conflict Location and Event Data. *Journal of Peace Research* 47(5) 651-660.

Schneider, Udo, Andreas Becker, Peter Finger, Anja Meyer-Christoffer, Bruno Rudolf and Markus Ziese (2015): GPCC Full Data Reanalysis Version 7.0 at 0.5°: Monthly Land-Surface Precipitation from Rain-Gauges built on GTS-based and Historic Data. doi:10.5676/DWD_GPCC/FD_M_V7_050

Schlenker, Wolfram, and David B Lobell. 2010. “Robust Negative Impacts of Climate Change on African Agriculture.” *Environmental Research Letters* 5(1): 1–11.

Tollefsen, Andreas Forø; Håvard Strand & Halvard Buhaug (2012) PRIO-GRID: A unified spatial data structure. *Journal of Peace Research*, 49(2): 363-374. doi: 10.1177/0022343311431287

The Economist (2016). The downside of authoritarian development: Ethiopia cracks down on protest, available at: http://www.economist.com/news/middle-east-and-africa/21708685-

once-darling-investors-and-development-economists-repressive-ethiopia Accessed 21 December, 2016

Vogt, Manuel, Nils-Christian Bormann, Seraina Rüegger, Lars-Erik Cederman, Philipp Hunziker, and Luc Girardin. 2015. "Integrating Data on Ethnicity, Geography, and Conflict: The Ethnic Power Relations Dataset Family." *Journal of Conflict Resolution*, 59(7), 1327-1342. doi:10.1177/0022002715591215

United Nations 2007, "*Development Strategies that Work*" *database*, available at: https://webapps01.un.org/nvp/indpolicy.action?id=124. Accessed 21 December, 2016

World Food Program (WFP) 2012, *Ethiopia Productive Safety Net Program Factsheet*

World Bank, *Ethiopia Overview 2016*. Available at: http://www.worldbank.org/en/country/ethiopia/overview Accessed 21 December, 2016

World Bank. 2006. *"Ethiopia Managing Water Resources to Maximize Sustainable Growth."* (36000): 119.

6. Food, Drought and Conflict: Evidence from a Case-Study on Somalia

Akresh, R., and D. de Walque, 2008. ''Armed Conflict and Schooling: Evidence from the 1994 Rwandan Genocide.'' IZA Discussion Papers 3516, Institute for the Study of Labor (IZA), HiCN Working Papers, 47.

Beguería, S., Vicente-Serrano S., Reig F., and B. Latorre (2014), "Standardized Precipitation Evapotranspiration Index (SPEI) revisited: parameter fitting, evapotranspiration models, tools, datasets and drought monitoring". *International Journal of Climatology*, 34(10): 3001–3023. doi: 10.1002/joc.3887

Buvinic, M. and G.R. Gupta (1997), Female-Headed Households and Female-Maintained Families: Are They Worth Targeting to Reduce Poverty in Developing Countries? *Economic Development and Cultural Change*, 45, 2, 259 - 280.

Caetano, C., 2015. A test of exogeneity without instrumental variables in models with bunching. *Econometrica*, 83(4):pp.1581–1600.

Caetano, G. and V. Maheshri, 2015. Identifying dynamic spillovers of crime: An empirical approach to model selection.

Devereux, S., 2006. Vulnerable Livelihoods in Somali Region, Ethiopia. IDS Research Report No. 57, Institute of Development Studies, Sussex.

Fan, Y. and H. van den Dool, 2008. “A global monthly land surface air temperature analysis for 1948-present”, *Journal of Geophysical Research*, 113, D01103, doi:10.1029/2007JD008470.

FAO, 2016. Dolow 2016 – “Evidence from mid-term review of the impact evaluation for the “Building Resilience in Somalia” joint strategy, Impact Evaluation Report 1.

FAO, 2016a. “Household Resilience in Somaliland. Baseline Analysis for Impact Evaluation of FAO-UNICEF-WFP Resilience Strategy”, Baseline Analysis for Impact Evaluation of FAO-UNICEF-WFP Resilience Strategy

FAO, 2016b. “Household Resilience in Puntland - Somalia. Baseline Analysis for Impact Evaluation of FAO-UNICEF-WFP Resilience Strategy”, Baseline Analysis for Impact Evaluation of FAO-UNICEF-WFP Resilience Strategy

Fafchamps, M. and A.R. Quisumbing, 2002. “Control and Ownership of Assets within Rural Ethiopian Households” In *Household Decisions, Gender, and Development. A Synthesis of Recent Research*. International Food Policy Institute, Washington D.C.

FSNAU and FEWSNET. 2011. Famine Spreads into Bay Region; 750,000 People Face Imminent Starvation Press release, September, 2011, Nairobi and Washington, DC. http://www.fsnau.org/

Gilbert, C.L., Morgan, C.W., 2010. Food price volatility. Philosophical Transactions of the Royal Society B: Biological Sciences 365, 3023-3034.

Hsiang, S. 2010. “Temperatures and Cyclones Strongly Associated with Economic Production in the Caribbean and Central America”. Proceedings of the National Academy of Sciences 107 (35): 15367–15372.

Maertens, R. 2016. “Adverse rainfall shocks and civil war: Myth or reality?”, Working paper Households in Conflict Network.

Maystadt, J.F., and G. Ecker, 2014. “Extreme weather and civil war: Does drought fuel conflict in Somalia through livestock price shocks?” *American Journal of Agricultural Economics* 96(4): 1157–1182

Maxwell, D., and M. Fitzpatrick. 2012. The 2011 Somalia Famine: Context, Causes, and Complications. *Global Food Security* 1 (1): 5–12.

Pettersson, T., and P. Wallensteen (2015) “Armed Conflicts, 1946-2014,” *Journal of Peace Research*. 52:4 536-550

Piot-Lepetit and M’Barek, 2011. “Methods to Analyse Agricultural Commodity Price Volatility”,

Raleigh et al., 2015. “The devil is in the details: An investigation of the relationships between conflict, food price and climate across Africa”. *Global Environmental Change*.

Weidmann, N. B., D. Kuse, and K. Skrede Gleditsch, 2010. "The geography of the international system: The CShapes Dataset". *International Interactions*, 36(1): 86-106.

Annexes

Food Security and Conflict: Analytic Framework and Typologies

Annex 1: Countries experiencing Low-intensity conflict 1994-2004, with average comparative undernourishment rates (Type 1)

Low-intensity Conflict Countries, 1993-2004	Average Prevalence of Undernourishment	Average Global Prevalence of Undernourishment	Difference
Rwanda	63.90	19.64	44.26
Angola	59.30	19.64	39.66
Haiti	57.00	19.64	37.36
Myanmar	56.64	19.64	37.00
Djibouti	56.60	19.64	36.96
Ethiopia	50.90	19.64	31.26
Chad	47.03	19.64	27.39
Georgia	45.65	19.64	26.01
Afghanistan	44.75	19.64	25.11
Congo, Republic of the	43.37	19.64	23.73
Central African Republic	42.50	19.64	22.86
Liberia	37.35	19.64	17.71
Tajikistan	36.50	19.64	16.86
Sierra Leone	36.42	19.64	16.78
Cambodia	33.60	19.64	13.96
Sudan	31.90	19.64	12.26
Niger	29.55	19.64	9.91
Uganda	28.98	19.64	9.34
Senegal	28.60	19.64	8.96
Peru	28.10	19.64	8.46
Yemen	27.90	19.64	8.26
Guinea	27.60	19.64	7.96
Guinea-Bissau	25.00	19.64	5.36
Iraq	23.90	19.64	4.26
Pakistan	23.10	19.64	3.46
Nepal	22.65	19.64	3.01
Philippines	21.74	19.64	2.10
India	19.62	19.64	-0.02
Mali	17.70	19.64	-1.94
Indonesia	17.35	19.64	-2.29
Thailand	16.90	19.64	-2.74
Cote d'Ivoire	16.50	19.64	-3.14
Lesotho	16.10	19.64	-3.54
Guatemala	15.35	19.64	-4.29
Colombia	9.84	19.64	-9.80
Nigeria	8.70	19.64	-10.94
Algeria	8.22	19.64	-11.42
Mexico	6.65	19.64	-12.99
Egypt	5.00	19.64	-14.64

Annex 2: Countries experiencing Low-intensity conflict 1994-2004, with average comparative Depth of Food Deficit rates (Type 1)

Low-intensity Conflict Countries, 1993-2004	Average Depth of Food Deficit	Average Global Food Deficit	Difference
Haiti	573.00	139.9	433.10
Rwanda	555.00	139.9	415.10
Djibouti	473.00	139.9	333.10
Myanmar	465.20	139.9	325.30
Angola	457.40	139.9	317.50
Georgia	412.50	139.9	272.60
Ethiopia	385.00	139.9	245.10
Chad	352.83	139.9	212.93
Congo, Republic of the	325.00	139.9	185.10
Central African Republic	316.00	139.9	176.10
Afghanistan	313.50	139.9	173.60
Liberia	286.75	139.9	146.85
Sierra Leone	278.17	139.9	138.27
Tajikistan	243.00	139.9	103.10
Cambodia	223.00	139.9	83.10
Sudan	219.50	139.9	79.60
Niger	202.50	139.9	62.60
Guinea	199.50	139.9	59.60
Uganda	196.75	139.9	56.85
Peru	195.00	139.9	55.10
Senegal	194.88	139.9	54.98
Yemen	174.00	139.9	34.10
Guinea-Bissau	172.00	139.9	32.10
Iraq	167.00	139.9	27.10
Pakistan	164.00	139.9	24.10
Nepal	153.50	139.9	13.60
Philippines	150.75	139.9	10.85
India	137.20	139.9	-2.70
Thailand	129.50	139.9	-10.40
Indonesia	123.17	139.9	-16.73
Cote d'Ivoire	115.67	139.9	-24.23
Mali	113.00	139.9	-26.90
Lesotho	105.00	139.9	-34.90
Guatemala	92.00	139.9	-47.90
Colombia	67.33	139.9	-72.57
Algeria	56.00	139.9	-83.90
Nigeria	53.00	139.9	-86.90
Mexico	45.50	139.9	-94.40
Egypt	25.00	139.9	-114.90

Annex 3: Countries experiencing Internationalized Interstate Conflict 1996-2014, with comparative Food Price Volatility Index Scores (Type 2)

Countries Affected by Internationalized Intrastate Conflict (IIC), 1996-2014	Average Food Price Volatility Index, IIC countries	Average Global Food Price Volatility Index	Difference
Angola	51.67	10.48	493%
Iraq	35.61	10.48	340%
Uganda	19.83	10.48	189%
Congo, Republic of the	19.30	10.48	184%
Rwanda	13.77	10.48	131%
Sierra Leone	13.70	10.48	131%
Yemen	12.38	10.48	118%
Mali	8.05	10.48	-77%
Nigeria	6.85	10.48	-65%
Mauritania	3.90	10.48	-37%
Ukraine	3.90	10.48	-37%

Annex 4: Countries experiencing Fragility 2006-2014, with comparative Cereal Import Dependency Ratio scores (Type 3)

List of Fragile States, 2006-2014	Fragile States, Average Cereal Import Dependency Ratio	Global Average, Cereal Import Dependency Ratio	Difference
Djibouti	100.00	32.12	67.88
Papua New Guinea	96.60	32.12	64.48
Solomon Islands	96.58	32.12	64.46
Vanuatu	95.60	32.12	63.48
Congo, Republic of the	90.60	32.12	58.48
Yemen	81.20	32.12	49.08
Mauritania	74.90	32.12	42.78
Comoros	72.30	32.12	40.18
Somalia	71.00	32.12	38.88
Liberia	64.03	32.12	31.91
Haiti	58.10	32.12	25.98
Angola	56.50	32.12	24.38
Cote d'Ivoire	52.73	32.12	20.61
Zimbabwe	48.28	32.12	16.16
Tajikistan	47.55	32.12	15.43
Eritrea	46.98	32.12	14.86
Gambia, The	44.08	32.12	11.96
Congo, Democratic Republic of	33.68	32.12	1.56
Guinea-Bissau	26.85	32.12	-5.27
Cameroon	25.80	32.12	-6.32
Sudan	25.53	32.12	-6.60
Sierra Leone	24.05	32.12	-8.07
Afghanistan	24.03	32.12	-8.10
Burundi	23.03	32.12	-9.10
Central African Republic	20.43	32.12	-11.69
Guinea	16.20	32.12	-15.92
Uzbekistan	15.98	32.12	-16.15
Nigeria	14.90	32.12	-17.22
Timor-Leste	14.13	32.12	-18.00
Togo	13.70	32.12	-18.42
Chad	8.48	32.12	-23.65
Cambodia	-1.63	32.12	-33.75
Myanmar	-2.55	32.12	-34.67
Laos	-3.43	32.12	-35.55

Annex 5: T-test results for mean comparison of income gap in agriculture and non-agricultural areas:

Two-sample t test with unequal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	1787	227.5728	3.077006	130.074	221.5378	233.6077
1	1653	240.0134	3.278957	133.3129	233.5821	246.4448
combined	3440	233.5508	2.246624	131.7679	229.1459	237.9556
diff		-12.44067	4.496613		-21.257	-3.62433

diff = mean(0) - mean(1)　　t = -2.7667
Ho: diff = 0　　Satterthwaite's degrees of freedom = 3402.23

Ha: diff < 0　　Ha: diff != 0　　Ha: diff > 0
Pr(T < t) = 0.0028　　Pr(|T| > |t|) = 0.0057　　Pr(T > t) = 0.9972

Annex 6: Two stage estimation results with a linear relationship in the second stage:

xtivreg	
Conflict onset	
Production	-0.537*** -0.104
excluded	0.071 -0.079
Lagged %Agricultural land	0.0002 -0.001
Lag_log population	0.558*** -0.104
_cons	-7.893*** -1.48
Wald chi2	766.1423
N	3403

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Annex 7: Regression tables

	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_drought	1.500	0.948**	2.669	2.016*			0.286	1.380
	(1.695)	(0.317)	(1.843)	(1.009)			(1.738)	(0.919)
lag_drought_sq			-1.031	-0.543			0.160	-0.318
			(1.225)	(0.550)			(0.755)	(0.458)
lag_stunting		0.761***		0.761***		0.551***		0.622***
		(0.066)		(0.063)		(0.083)		(0.090)
temp					2.565***	1.419**	2.659***	1.139*
					(0.755)	(0.492)	(0.770)	(0.499)
_cons	22.441***	2.974	23.287***	3.009	-54.896**	-36.019**	-58.077**	-29.165*
	(4.048)	(2.009)	(4.269)	(1.904)	(23.462)	(13.362)	(23.502)	(12.807)
Pseudo R-squared	0.014	0.627	0.027	0.630	0.236	0.583	0.250	0.652
N	324	248	324	248	377	276	324	248

Table 1 Dep var: percentage underweight individuals and stunted individuals. Regressions are run without time and district dummies, using ols regression with standard errors clustered at the district level. The drought variables are lagged one time period, the variable *lag_stunting* is lagged 3 time periods.

	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_drought	3.789***	4.867	-2.644	-1.042	2.219**	1.202	-7.064	(3.935)
	(0.271)	(3.540)	(1.567)	(0.937)	(0.687)	(0.555)	(3.342)	1.275
lag_drought_sq	-2.705*	-2.116	-2.662***	-0.493	-0.025	-0.240	1.832	(1.282)
	(0.795)	(2.908)	(0.505)	(0.560)	(0.858)	(0.097)	(0.972)	0.843**
lag_stunting		0.458		0.430		0.781**		
		(0.329)		(0.230)		(0.125)		
_cons	17.254*	5.669	37.532***	16.417	15.511**	1.836	32.819**	1.801
	(4.061)	(6.663)	(3.856)	(9.837)	(4.076)	(1.292)	(6.935)	(5.211)
Pseudo R-squared	0.338	0.379	0.173	0.257	0.062	0.715	0.066	0.729
N	45	32	85	76	107	83	67	57
Livelihood	urban	urban	agropastoral	agropastoral	pastoral	pastoral	riverine	riverine

Table 2 Dep var: percentage underweight individuals and stunted individuals. Results are depicted by livelihood (urban, agropastoral, pastoral, and riverine). Regressions are run without time and district dummies, using ols regression with standard errors clustered at the district level. The drought variables are lagged one time period, the variable *lag_stunting* is lagged 3 time periods.

	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting	pcunderweight	pcstunting
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_onesided	0.640	0.936						
	(0.795)	(2.316)						
lag_intrastate			2.718***	-1.582				
			(0.808)	(0.903)				
lag_internationalized					-0.330	-0.424		
					(1.058)	(0.914)		
lag_internationalized					-0.330	-0.424		
					(1.058)	(0.914)		
lag_lowintensity							1.675	-1.365
							(1.919)	(2.206)
lag_stunting		0.233		0.234		0.227		0.228
		(0.149)		(0.157)		(0.154)		(0.155)
events_history	-0.074	-0.048	-0.092*	-0.029	-0.072	-0.044	-0.076	-0.039
	(0.049)	(0.075)	(0.047)	(0.074)	(0.049)	(0.071)	(0.043)	(0.077)
lnpop	-1.179	0.216	-2.677	1.883	-1.005	0.604	-1.003	0.923
	(2.402)	(2.754)	(2.167)	(2.497)	(2.438)	(2.263)	(1.886)	(2.590)
capdist	-0.000	-0.043	0.039	-0.066	-0.001	-0.052	-0.060	-0.034
	(0.133)	(0.172)	(0.118)	(0.170)	(0.137)	(0.176)	(0.118)	(0.191)
_cons	22.351	26.262	8.595	0.967	20.818	21.055	68.227	12.735
	(97.658)	(62.772)	(91.552)	(61.908)	(101.195)	(58.242)	(87.642)	(68.069)
Pseudo R-squared	0.789	0.678	0.797	0.680	0.789	0.678	0.801	0.678
N	362	276	362	276	362	276	332	276
district and time dummies	yes	yes	yes	yes	yes	yes	yes	yes

Table3 Dep var: percentage underweight individuals and stunted individuals Regressions are run with time and district dummies, using ols regression with standard errors clustered at the district level. The variable *lag_stunting* is lagged 3 time periods.

	pcunderweight	pcunderweight	pcunderweight	pcunderweight	pcstunting	pcstunting	pcstunting	pcstunting
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_onesided	1.599				-3.352			
	(1.418)				(1.756)			
lag_intrastate		3.311***				2.084		
		(1.047)				(1.908)		
lag_internationalized			-0.346				0.773	
			(1.340)				(1.528)	
lag_lowintensity				3.276				-0.407
				(2.833)				(1.196)
lag_stunting					0.091	0.022	0.043	0.052
					(0.164)	(0.156)	(0.169)	(0.170)
events_history	-0.034	-0.059	-0.027	-0.038	-0.111	-0.132	-0.123	-0.115
	(0.049)	(0.043)	(0.046)	(0.049)	(0.107)	(0.114)	(0.116)	(0.110)
lnpop	1.702	-0.788	1.943	0.826	0.715	-1.006	0.527	0.890
	(2.060)	(1.830)	(1.972)	(1.970)	(2.384)	(3.461)	(2.498)	(2.412)
capdist	-0.049	-0.086	-0.059	-0.125	-0.481**	-0.392**	-0.437*	-0.394*
	(0.182)	(0.169)	(0.182)	(0.181)	(0.233)	(0.198)	(0.235)	(0.209)
Pseudo R-squared	0.031	0.093	0.023	0.047	0.094	0.089	0.074	0.073
N	207	207	207	207	153	153	153	153

Table 4 Dep var: percentage underweight individuals and stunted individuals. Regressions are run using ols regression with standard errors adjusted for spatial and temporal correlation. The variable *lag_stunting* is lagged 3 time periods.

	onesided	intrastate	internat	lowintens	onesided	intrastate	internat	lowintens	onesided	intrastate	internat	lowintens
	est1	est2	est3	est4	est5	est6	est7	est8	est9	est10	est11	est12
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_drought	0.121	0.110	-0.006	0.012	0.101	0.100	-0.004	0.009				
	(0.087)	(0.110)	(0.025)	(0.008)	(0.085)	(0.115)	(0.029)	(0.007)				
lag_drought_sq					0.031	0.016	-0.004	0.005				
					(0.023)	(0.023)	(0.009)	(0.003)				
temp									0.008	0.019	0.013***	0.002*
									(0.010)	(0.015)	(0.005)	(0.001)
_cons	0.335*	0.443	0.152**	0.038***	0.307*	0.429	0.155**	0.033***	-0.012	-0.277	-0.299**	-0.024
	(0.149)	(0.269)	(0.061)	(0.009)	(0.156)	(0.281)	(0.067)	(0.009)	(0.239)	(0.326)	(0.118)	(0.025)
Pseudo R-squared	0.005	0.001	0.000	0.004	0.006	0.001	0.000	0.006	0.000	0.001	0.004	0.001
N	7656	7656	7656	8566	7656	7656	7656	8566	16068	16068	16068	21036

Table 5 Dep var: conflict indicators. Regressions are run without time and district dummies, using ols regression with standard errors clustered at the district level.

	onesided	intrastate	internat	lowintens	onesided	intrastate	internat	lowintens	onesided	intrastate	internat	lowintens	onesided	intrastate	internat	lowintens
	est1	est2	est3	est4	est5	est6	est7	est8	est9	est10	est11	est12	est13	est14	est15	est16
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_drought	0.093	0.037	-0.022	0.008	0.105	0.089	-0.003	0.009					0.082*	0.090	0.002	0.009*
	(0.060)	(0.057)	(0.025)	(0.007)	(0.064)	(0.084)	(0.026)	(0.006)					(0.048)	(0.080)	(0.018)	(0.005)
lag_drought_sq					-0.017	-0.074	-0.028	-0.002					-0.016	-0.076	-0.029	-0.003
					(0.028)	(0.068)	(0.017)	(0.002)					(0.028)	(0.070)	(0.017)	(0.003)
temp									0.028	-0.020	-0.017	0.002	0.065	0.021	-0.007	0.008
									(0.035)	(0.026)	(0.015)	(0.005)	(0.058)	(0.045)	(0.023)	(0.007)
_cons	1.145***	1.656**	0.724***	-0.044***	-0.031	0.001	-0.013	-0.040***	-0.655	0.868	0.561	-0.083	-2.221	-0.871	0.344	-0.214
	(0.389)	(0.772)	(0.220)	(0.012)	(0.104)	(0.084)	(0.026)	(0.013)	(1.188)	(0.905)	(0.499)	(0.159)	(1.700)	(1.344)	(0.679)	(0.210)
Pseudo R-squared	0.355	0.304	0.221	0.213	0.356	0.306	0.224	0.213	0.330	0.287	0.199	0.161	0.358	0.307	0.225	0.221
N	7656	7656	7656	8566	7656	7656	7656	8566	16068	16068	16068	21036	7308	7308	7308	7660

Table 6 Dep var: conflict indicators. Regressions are run with time and district dummies, using ols regression with standard errors clustered at the district level.

	price	price	volatility	volatility	price	volatility	price	price	price	price	volatility	volatility	volatility	volatility
	est1	est2	est3	est4	est5	est6	est7	est8	est9	est10	est11	est12	est13	est14
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_drought	-0.026*	-0.027*	-0.003	0.003			0.022*		0.023*		0.009		0.004	
	(0.012)	(0.013)	(0.006)	(0.006)			(0.009)		(0.008)		(0.006)		(0.004)	
lag_drought_sq		0.002		-0.005*			-0.009*		-0.009*				-0.000	
		(0.005)		(0.002)			(0.003)		(0.003)				(0.001)	
temp					-0.022*	0.008*		0.013		0.012		0.006		0.007
					(0.009)	(0.002)		(0.013)		(0.013)		(0.005)		(0.005)
lnpop									-0.010	-0.008			0.007	0.008
									(0.010)	(0.008)			(0.007)	(0.005)
capdist									0.003	0.001			0.001	0.000
									(0.002)	(0.001)			(0.001)	(0.001)
_cons	0.487*	0.486*	0.189*	0.192*	1.150*	-0.081	0.880*	0.653*	-1.646	-0.888	0.150*	0.042	0.089	-0.109
	(0.032)	(0.033)	(0.015)	(0.015)	(0.253)	(0.070)	(0.025)	(0.305)	(2.019)	(1.466)	(0.052)	(0.124)	(0.100)	(0.171)
Pseudo R-squared	0.009	0.009	0.000	0.002	0.081	0.054	0.518	0.522	0.524	0.526	0.325	0.497	0.498	0.500
N	4720	4720	3557	3557	5219	3960	4720	5219	4489	5195	3557	3960	3413	3936
district and time dummies	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes

Table 7: Dep var food security indicators: the normalized maize-sorghum price index and volatility measure. All regressions include district and time fixed effects, using ols regression with standard errors clustered at the district level.

	price	volatility	price	volatility	price	volatility	price	volatility
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_onesided	-0.001	-0.000						
	(0.003)	(0.002)						
lag_intrastate			-0.003	-0.000				
			(0.004)	(0.002)				
lag_internationalize					-0.001	-0.003		
					(0.005)	(0.002)		
lag_lowintensity							-0.014	-0.007
							(0.015)	(0.009)
events_history	0.000	-0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lnpop	-0.009	0.007	-0.008	0.007	-0.009	0.007	-0.009	0.007
	(0.008)	(0.005)	(0.008)	(0.006)	(0.008)	(0.005)	(0.008)	(0.005)
capdist	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
_cons	-0.414	-0.208	-0.425	-0.206	-0.410	-0.202	-0.531	-0.411
	(1.286)	(0.718)	(1.272)	(0.717)	(1.290)	(0.713)	(1.369)	(0.704)
Pseudo R-squared	0.527	0.489	0.527	0.489	0.527	0.489	0.525	0.497
N	5155	3878	5155	3878	5155	3878	5195	3936
district and time dummies	no	no	no	no	no	no	yes	yes

Table 8: Dep var conflict indicators. All regressions include district and time fixed effects, using ols regression with standard errors clustered at the district level.

	price	price	price	price	volatility	volatility	volatility	volatility
	est1	est2	est3	est4	est5	est6	est7	est8
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
lag_onesided	0.005*				-0.001			
	(0.003)				(0.002)			
lag_intrastate		0.003				0.002		
		(0.002)				(0.001)		
lag_internationalized			0.002				0.002*	
			(0.002)				(0.001)	
lag_lowintensity				-0.018*				-0.000
				(0.008)				(0.004)
events_history	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lnpop	-0.005	-0.004	-0.004	-0.002	0.003	0.001	0.002	0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
capdist	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000
Pseudo R-squared	0.007	0.006	0.006	0.007	0.004	0.006	0.005	0.004
N	1269	1269	1269	1269	999	999	999	999

Table 9: Dep var food security indicators: the normalized maize-sorghum price index and volatility measure. Regressions are run using ols regression with standard errors adjusted for spatial and temporal correlation.

	fcs	food_exp	nonfood_exp	fcs	food_exp	nonfood_exp	fcs	food_exp	nonfood_exp	fcs	food_exp	nonfood_exp
	est1	est2	est3	est4	est5	est6	est7	est8	est9	est10	est11	est12
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
drought	7.066***	0.707***	0.341***				4.072***	0.189***	0.282***	4.482***	0.142	0.235***
	(0.000)	(0.000)	(0.000)				(0.000)	(0.000)	(0.000)	(0.367)	(0.074)	(0.035)
temp				-8.342***	-1.229***	-0.540***	-6.274***	-1.085***	-0.124***	-4.584***	-0.832***	0.094
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.707)	(0.128)	(0.068)
log_formal_transfer										0.053	0.005	-0.027
										(0.067)	(0.030)	(0.022)
log_informal_transfer										-0.130	-0.033	-0.010
										(0.153)	(0.028)	(0.006)
femhead										-0.084	-0.314	-0.452**
										(0.217)	(0.652)	(0.116)
hhsize										0.199	0.048**	0.047***
										(0.253)	(0.012)	(0.008)
educhead										0.363	-0.025	-0.001
										(0.301)	(0.032)	(0.023)
log hh income										0.287	0.103	0.189**
										(0.355)	(0.083)	(0.056)
distance_market										0.027	0.010*	0.001
										(0.019)	(0.003)	(0.001)
distance_health										-0.002	-0.001	-0.000
										(0.005)	(0.001)	(0.000)
shagr_wge										2.510	0.544	0.326
										(11.048)	(0.284)	(0.591)
shnonagr_wge										0.438	-0.606*	-0.048
										(4.472)	(0.239)	(0.072)
shcrop										-6.240***	-0.935	-0.743*
										(1.000)	(0.583)	(0.258)
shlivestock										1.599	-1.502*	-0.738
										(2.291)	(0.541)	(0.321)
shselfemp										-3.313	-1.116	-0.273
										(2.649)	(0.729)	(0.203)
shtransfer										-2.929	0.520	1.499
										(2.450)	(0.829)	(0.650)
_cons	47.761***	12.175***	12.543***	279.033***	46.433***	27.574***	222.964***	42.485***	15.997***	171.707***	35.195***	7.959**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(19.975)	(3.958)	(2.370)
Pseudo R-squared	0.159	0.065	0.060	0.159	0.065	0.060	0.159	0.065	0.060	0.182	0.084	0.149
N	1564	1591	1591	1564	1591	1591	1564	1591	1591	1195	1212	1212
district FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Table 10: Dep var imputed food security score, food expenditures, and non-food expenditures. Regressions are run with district dummies, using ols regression with standard errors clustered at the district level.

	conflict	conflict	conflict	conflict	conflict
	est1	est2	est3	est4	est5
	b/se	b/se	b/se	b/se	b/se
drought	0.105		0.140***		0.133***
	(0.045)		(0.000)		(0.000)
temp		-0.084		0.000***	-0.015***
		(0.107)		(0.000)	(0.000)
_cons	0.148**	2.521	0.171***	0.093***	0.592***
	(0.031)	(2.975)	(0.000)	(0.000)	(0.000)
Pseudo R-	0.032	0.005	0.057	0.057	0.057
N	1570	1570	1570	1570	1570
district FE	no	no	yes	yes	yes

Table 11: Dep var conflict exposure. Regressions are run with and without district dummies (as indicated), using ols regression with standard errors clustered at the district level.

	fcs	food_exp	nonfood_exp
	est1	est2	est3
	b/se	b/se	b/se
conflict	3.053*	0.162	-0.144***
	(1.033)	(0.100)	(0.024)
log formal transfer	-0.000	0.000	-0.000**
	(0.000)	(0.000)	(0.000)
log informal transfer	0.000	0.000	0.000***
	(0.000)	(0.000)	(0.000)
femhead	0.234	-0.294	-0.445**
	(0.164)	(0.652)	(0.107)
hhsize	0.180	0.046*	0.050**
	(0.256)	(0.015)	(0.010)
educhead	0.381	-0.027	-0.002
	(0.308)	(0.035)	(0.024)
log hh income	0.247	0.096	0.170**
	(0.350)	(0.070)	(0.052)
distance_market	0.024	0.010*	0.001
	(0.019)	(0.004)	(0.001)
distance_health	-0.001	-0.001	-0.000
	(0.005)	(0.001)	(0.000)
shagr_wge	2.497	0.481	0.402
	(11.504)	(0.413)	(0.471)
shnonagr_wge	1.290	-0.528	0.063
	(4.202)	(0.296)	(0.082)
shcrop	-5.289**	-0.833	-0.729*
	(1.475)	(0.578)	(0.234)
shlivestock	2.089	-1.464*	-0.680
	(1.941)	(0.613)	(0.317)
shselfemp	-2.588	-1.029	-0.233
	(2.295)	(0.718)	(0.203)
shtransfer	-4.241	0.186	1.088*
	(5.060)	(0.579)	(0.449)
_cons	39.675***	11.624***	10.658***
	(2.881)	(1.375)	(0.582)
Pseudo R-squared	0.194	0.085	0.149
N	1180	1196	1196
district FE	yes	yes	yes

Table 12: Dep var imputed food security score, food expenditures, and non-food expenditures. Regressions are run with district dummies, using ols regression with standard errors clustered at the district level.

	fcs	food_exp	nonfood_exp	fcs	food_exp	nonfood_exp
	est1	est2	est3	est4	est5	est6
	b/se	b/se	b/se	b/se	b/se	b/se
treatment	1.258	0.141*	0.063	-12.270	0.125	4.735***
	(0.912)	(0.016)	(0.069)	(4.132)	(0.107)	(0.022)
drought				37.607	0.044	-12.988***
				(8.395)	(0.253)	(0.060)
femhead	2.730	-0.002	-0.028	2.722	-0.002	-0.025
	(3.546)	(0.238)	(0.241)	(3.549)	(0.238)	(0.240)
hhsize	0.561	0.046	0.058	0.560	0.046	0.059
	(0.587)	(0.024)	(0.036)	(0.587)	(0.024)	(0.036)
educhead	0.064	-0.004	0.028	0.066	-0.004	0.027
	(0.022)	(0.022)	(0.020)	(0.021)	(0.022)	(0.021)
log hh income	0.002	0.000	0.000	0.002	0.000	0.000
	(0.002)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
distance_market	4.386	-0.166	0.301*	4.426	-0.166	0.287**
	(3.086)	(0.094)	(0.027)	(3.078)	(0.094)	(0.021)
distance_health	3.616	0.360*	0.169	3.598	0.360*	0.175
	(1.402)	(0.032)	(0.172)	(1.404)	(0.032)	(0.171)
shagr_wge	10.607	0.660	0.614	10.594	0.660	0.618
	(4.218)	(0.248)	(0.116)	(4.214)	(0.248)	(0.114)
shnonagr_wge	0.066**	0.002	-0.003	0.066*	0.002	-0.003
	(0.005)	(0.002)	(0.001)	(0.005)	(0.002)	(0.001)
shcrop	2.581	-0.056	0.002	2.583	-0.056	0.001
	(5.637)	(0.294)	(0.135)	(5.653)	(0.294)	(0.130)
shlivestock	0.823	0.139	-0.093	0.794	0.139	-0.083
	(2.164)	(0.043)	(0.075)	(2.164)	(0.044)	(0.077)
shselfemp	11.054	0.288	0.509	11.042	0.288	0.513
	(3.865)	(0.147)	(0.246)	(3.862)	(0.148)	(0.248)
drought_3_SPEI_all				37.607	0.044	-12.988***
				(8.395)	(0.253)	(0.060)
_cons	61.921*	6.834**	5.897*	7.306	6.771*	24.759**
	(6.239)	(0.274)	(0.520)	(18.534)	(0.642)	(0.574)
Pseudo R-squared	0.108	0.039	0.652	0.108	0.039	0.655
N	926	926	926	926	926	926

Table 12: Dep var imputed food security score, food expenditures, and non-food expenditures. Regressions are run using the difference-in-difference approach, including district and year dummies and standard errors clustered at the district level.